The London School of Economics and Political Science

Essays on Gender Inequality in the Labour Market

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Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I declare that my thesis consists of 64,050 words.

Statement of co-authored work

I confirm that Chapter 4 was jointly co-authored with Dr. Mireia Borrell-Porta and Dr. Joan Costa-Font, and I contributed 55 percent of this work. I confirm that Chapter 5 was jointly co-authored with Dr. Cevat Giray Aksoy and Dr. Berkay Özcan, and I contributed 66 percent of this work. Details of the contributions are provided in the table below.

Table of authorship contributions

Aspect of research	Chapter 4 contributing authors	Chapter 5 contributing authors
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Abstract

Despite substantial progress, gender gaps in labour market outcomes persist. Several key factors help explain remaining gaps. First, men and women continue to work in different jobs. Second, parenthood appears to be a crucial point in the life course at which gender gaps widen. Third, traditional beliefs and norms about the appropriate roles of men and women, particularly in the context of parenthood, are obstacles to closing remaining gender gaps. At the same time, advancements in automation technologies are transforming the world of work and may have gender-specific impacts.

Motivated by these observations, this thesis advances understanding of several factors related to gender inequality in the labour market. These factors are gendered university major choices, attitudes towards gender roles in the context of parenthood, and effects of recent transformations in labour markets on the gender gap in pay. The thesis consists of four empirical papers.

The first paper studies the role of intergenerational transmission for gendered university major choices of young adults. Using regression analysis and exploiting survey data from a recent cohort of university students in Germany, the paper investigates to what extent and why gender-typicality of mother's and father's occupation affect the gender-typicality of their child's university major. Results show significant intergenerational associations and indicate that parental resources and a transmission of gender roles are both relevant transmission channels, particularly for sons' major choices.

The second and third paper examine how gender role attitudes are shaped in the context of parenthood. The second paper analyses effects of the 2007 paid parental leave reform (Elterngeld) in Germany on parents' gender role attitudes; specifically, attitudes towards the gender division of work, towards the roles of fathers, and towards the labour force participation of mothers. Exploiting the reform as a natural experiment, results indicate that men affected by the reform hold more traditional attitudes towards the role of fathers, whereas there is no effect on the other two

outcomes.

Focusing on the UK, the third paper explores whether parenting daughters affects attitudes towards a traditional male breadwinner model in which it is the husband's role to work and the wife's to stay at home. Using panel data and individual fixed effects models, the results indicate that fathers are less likely to hold traditional views on the gender division of work if they raise a girl. No robust effects on mothers' attitudes are found. Results from the second and third paper inform the broader literature on attitudinal change, suggesting that gender role attitudes are not stable throughout the life course and can be significantly shaped by adulthood experiences.

The final paper studies whether technological change increases gender inequality. Using individual-level data from around 28 million individuals in 20 European countries and an instrumental variable strategy, the study provides the first large-scale evidence concerning the impact of industrial robots on the gender gap in earnings. Findings indicate that robot adoption increases both male and female earnings but also increases the gender pay gap. These results are driven by countries with high initial levels of gender inequality and can be explained by the fact that men in medium- and high-skilled occupations disproportionately benefit from robotization, through a productivity effect.

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Chapter 1

Introduction

This thesis focuses on three aspects of gender inequality in the labour market. These aspects are gendered university major choices, traditional attitudes towards gender roles in the context of parenthood, and the gender gap in pay. The thesis consists of four stand-alone empirical papers. The common motivation behind all papers is to improve understanding of some key sources of gender differences in labour market outcomes.

Achieving gender equality and empowering all women and girls is one of the 17 UN Sustainable Development Goals adopted in 2015. Equality in the labour market constitutes a key part within this goal of gender equality. However, it is not only from a fairness perspective that women and men should have the same set of opportunities in the labour market. Research shows that greater gender equality also increases competitiveness and economic growth (Cuberes & Teignier 2016, Hsieh et al. 2019).

This introductory chapter is structured as follows. Section 1.1 situates the papers in the broader economics literature by highlighting some key areas and factors relevant to remaining gender gaps in the labour market. It does not, however, attempt to provide a comprehensive review of the literature on the sources of gender gaps.[1] Section 1.2 states the aims of the thesis and provides relevant definitions.

[1]For recent reviews see, for example, Blau & Kahn (2017), Kunze (2018), and Bertrand (2020).

Section 1.3 gives an outline of the remaining thesis chapters and a summary of each of the papers.

1.1 Background

Progress towards closing gender gaps in the labour market

The convergence in the roles of men and women constitutes one of the most significant changes of the twentieth century (Goldin 2014, Olivetti & Petrongolo 2017). Dramatic shifts in women's educational and labour market behaviour have resulted in the narrowing of gender gaps in labour force participation, earnings, educational levels, university majors, and occupations. At the same time, differences between men and women in time spent on paid and unpaid work have declined (Gimenez-Nadal & Sevilla 2012).

This narrowing of gender gaps has continued into the 21st century. For example, the average OECD gender employment gap decreased from 17 percentage points in 2000 to 11 percentage points in 2018 (OECD 2020). Moreover, young women today are more likely to possess a tertiary qualification than young men in every OECD country (OECD 2020).

Despite this progress, substantial gender differences in labour market outcomes remain. In 2018, the average unadjusted gender gap in median earnings of full-time employees across OECD countries was still at 13 percent (OECD 2020). That is, for every Euro earned by the median man, the median woman earned 87 cents. The gender pay gap can be interpreted as a summary statistic reflecting many aspects and underlying layers of gender inequality. These aspects include, among others, women's underrepresentation in high-paying occupations and in top positions, discrimination, the part-time pay penalty, and career costs associated with having children.

There is also evidence suggesting that progress towards closing remaining gender gaps has slowed over the last two to three decades. For example, the increase in

women's labour force participation and the reduction in occupational sex segregation have slowed or plateaued since the 1990s (Goldin 2014, Blau & Kahn 2017).

Key areas of remaining gender differences

Recent research emphasises two key contributing factors for why women's labour market outcomes still lag behind those of men (see Bertrand 2020). Both of these factors highlight that the different choices that men and women pursue at key stages in the life course translate into important gender inequalities in labour market achievements.

First, despite the fact that young women in OECD countries today are more likely to obtain a tertiary degree than young men, they continue to choose different university majors (Ponthieux & Meurs 2015, OECD 2020). Men tend to select high-paying STEM fields. Women, on the other hand, are more likely to choose lower-paying fields such as humanities. These university major choices account for a sizeable part of subsequent gender earnings gaps (Brown & Corcoran 1997, Machin & Puhani 2003, Black et al. 2008). A recent study based on data from the US shows that the degree choices (combination of highest degree and university major for those with at least a four-year college degree) of women born in 1985 map into 6 percent lower average earnings and 10 percent lower 90th percentile earnings compared to men (Bertrand 2018). Moreover, Bertrand's (2018) study shows that the gender gap in expected earnings based on educational degree has remained more or less unchanged since birth cohorts of the late 1960s.

Such horizontal segregation is not limited to those with university degrees. Across educational levels, women and men continue to work in different occupations. Despite a substantial decline since the 1970s, occupational sex segregation remains large (Blau & Kahn 2017). US data indicates that occupational differences between women and men explain roughly one third of the gender wage gap in 2010 and thus remain important for explaining remaining pay gaps (Blau & Kahn 2017).[2]

[2]On the other hand, human capital factors such as educational level and labour market experience explained little of the gender pay gap by 2010 (Blau & Kahn 2017).

A second and widely discussed key factor preventing progress towards achieving gender equality is the unequal effect of parenthood on men's and women's labour market outcomes (e.g. Waldfogel 1998, Angelov et al. 2016, England et al. 2016). This is commonly referred to as the 'motherhood penalty'. When entering parenthood, men's labour market behaviour remains largely unchanged. In contrast, women drastically adjust their labour market behaviour, for example, by exiting the labour force or working fewer hours (Angrist & Evans 1998). These behavioural changes translate into large and long-lasting pay penalties for women.

For example, a recent study estimates the effect of the birth of a first child on parental earnings across six different countries (Kleven et al. 2019). Results show a large and persistent drop in the earnings of mothers that occurs after the birth of the first child while leaving fathers' earnings largely unchanged. The long-run penalty (defined as the average loss in gross labour earnings unconditional on employment status) five to ten years after the first birth ranges from 21 percent in Denmark to 61 percent in Germany. These figures highlight the importance of motherhood pay penalties for remaining gender inequalities in labour market outcomes.

Traditional gender roles as an explanation for gendered choices

The discussion of two important areas in which gender gaps are particularly apparent highlights that these gaps are caused by the different choices that men and women make at key stages throughout the life-course. This leads to the question of what the underlying sources for such different choices are. In the case of the motherhood pay gap, evidence suggests a surprisingly limited role of traditional economic factors, such as relative education, as well as a limited role of family policy (Kleven et al. 2019).

A more recent strand of research focuses on gender differences in psychological traits and preferences (Niederle 2017). For example, women are less likely to negotiate over salaries, have a lower inclination for competitiveness, and are on average more risk averse than men (Croson & Gneezy 2009, Bertrand 2011, Niederle 2017).

Another explanation for gender differences in labour market outcomes, which

is now widely discussed in the economics literature, is the persistence of gender social norms and traditional gender role attitudes (e.g. Bertrand 2014, Ponthieux & Meurs 2015). This strand of research was in part sparked by the fact that a sizeable component of gendered labour market outcomes and behaviour could not be explained by 'traditional' factors considered in economics (Blau & Kahn 2017).

Much of the empirical research on gender norms within economics draws on the work of Akerlof & Kranton (2000) on social identity. Their work brought the concept of social identity, originally developed as a theory of intergroup conflict within social psychology (Tajfel & Turner 1979), into mainstream economics by incorporating identity into the framework of individual utility. The basic idea is that people make economic choices not only based on monetary considerations, but also based on their social identity and the norms that prescribe appropriate behaviour. Applications of the concepts of social identity and social norms are now found in many areas in economic research, for example, attitudes towards redistribution (Costa-Font & Cowell 2015), savings behaviour (Costa-Font et al. 2018), and partnership formation rates (Gimenez-Nadal et al. 2012).

Several studies demonstrate the relevance of gender social norms and gender beliefs for gendered labour market behaviour. For example, traditional attitudes towards gender roles are associated with lower female labour force participation and higher gender pay gaps across a sample of OECD countries (Fortin 2005). Similarly, women with more traditional gender role attitudes are less likely to enter and more likely to exit the labour force (Khoudja & Platt 2018). Moreover, cultural proxies from second-generation immigrant American women's country of ancestry affect their work and fertility behaviour (Fernández & Fogli 2009). Bertrand et al. (2015) show that the traditional belief that a wife should not earn more than her husband affects the relative income within households, which suggests that couples try to avoid a situation in which the wife earns more than her husband. Moreover, if the situation in which the wife earns more than her husband arises, women exhibit compensating behaviour such as spending more time on household tasks, and they are more likely to exit the labour force. These findings illustrate that the presence

of social norms is an important concern, not only because of their effect on pay gaps, but also because seemingly voluntary choices can perpetuate gender differences.

Traditional gender roles and norms may help explain why women and men continue to choose different university majors and occupations. These factors may also explain part of the persistence of motherhood pay penalties. In line with this possibility, Kleven et al. (2019) show a strong correlation between traditional attitudes towards gender roles and long-run motherhood pay penalties across countries, while the latter do not appear to be driven by family policy.

One's adherence to traditional gender social norms does not need to be conscious. Nevertheless, the narrowing of gender gaps has gone hand in hand with trends in stated gender beliefs. Individuals' attitudes towards the appropriate roles of men and women concerning paid work and non-paid domestic work have substantially modernised. For example, the share of West Germans supporting a gender-egalitarian division of roles in paid and domestic work increased from 61 percent in 2000 to 86 percent in 2016 (Blohm & Walter 2018). These common trends in attitudes and behaviour suggest that individuals act upon their less traditional views and that the increasing incidence of less gender traditional division of roles influences gender role attitudes (Blau & Kahn 2017).

The persistence of traditional gender roles and the role of exogenous events for triggering change

The evidence on the relevance of gender norms for gender inequality in labour market outcomes raises the question of what determines the formation of such norms and beliefs, and how they can be changed.

Some work suggests the persistence of norms in the long term. For example, Alesina et al. (2013) present evidence that countries in which forms of plough cultivation that were less suited to female labour were prevailing, still exhibit greater gender inequality and less egalitarian attitudes towards gender roles today. In line with the notion that norms persist in the long run, research suggests that gender role attitudes are transmitted intergenerationally. Such intergenerationally transmitted

attitudes, formed during childhood and youth, have consequences for later labour market behaviour (Farré & Vella 2013, Platt & Polavieja 2016). In addition to the role of parental attitudes, parents' labour market behaviour is also an important predictor of children's gender role attitudes (Platt & Polavieja 2016). Similarly, Fernández et al. (2004) show that men who grew up with a working mother are more likely to have working wives. These men may have less traditional gender role attitudes concerning the gender division of roles within the household. All of this evidence points to a formation of gender role attitudes early in life.

In contrast, other work shows that exogenous events can contribute to fairly rapid changes in gender norms. For example, Goldin & Katz (2002) demonstrate that the invention of the birth control pill altered women's career and marriage decisions. The findings suggest that this innovation in contraception contributed to a change in women's gender role identity (Bertrand 2014). Another recent study demonstrates that exposure to gender-egalitarian settings can change traditional behaviour (Boelmann et al. 2020). The paper provides evidence that mothers who grew up in the gender-traditional West German culture and who migrated to the more gender-egalitarian East Germany after reunification adjust their post-birth labour supply behaviour to that of their East German colleagues. That is, they return to work faster and work longer hours.

A reversal of progress and a reinforcement of traditional gender roles triggered by exogenous events is also possible. New research shows that Covid-19 lockdowns increased gender inequalities in unpaid work in Spain (Farré et al. 2020) and in England (Andrew et al. 2020). While men are found to increase their time spent on childcare and housework, mothers were still shouldering most of the burden.

Exogenous events do not only affect gender inequality via their effect on gender roles and social norms. Existing gender inequalities can also be directly impacted by such 'demand-side factors' (Blau & Kahn 2017). Technological change is a prominent example. The slowing progress towards closing the remaining gender pay gap coincided with rapid changes in the nature of work and the demand for skills due to technological advances. Paying attention to these profound changes in labour mar-

kets is important when it comes to providing solutions to closing remaining gender gaps. Moreover, it is possible that contexts in which gender norms and attitudes are less traditional are better equipped for the gendered impacts of exogenous shocks to labour markets.

1.2 Aims and relevant definitions

The discussion in Section 1.1 demonstrates that despite progress, gender differences in labour market outcomes remain ubiquitous. While by no means a comprehensive list, two important aspects of these gaps are the fact that men and women continue to choose different jobs, and the gendered career consequences of parenthood. To explain these phenomena, the literature has increasingly focused on the role of traditional norms and attitudes. While traditional norms can persist in the long run, there is also evidence that exogenous events can trigger fairly rapid change. Against this background, the empirical papers in this thesis take these insights as starting points and explore one or more of them in-depth. Specifically, the thesis papers focus on the following important areas of remaining gender differences as outcome variables: gender-typical university major choices, attitudes towards gender roles, and gender gaps in earnings.

In so doing, a first aim is to improve understanding of some of the factors that help explain the persistence of gender differences in the labour market. A second aim is to examine whether gender role attitudes adapt to changes in social policy and experiences. The overall motivation is to improve knowledge of important underlying sources for why men and women continue to have different career outcomes.

Given the importance of gender social norms identified in the literature, the papers in Chapters 2, 3 and 4 focus on gender roles, at three distinct life course stages: entry to university, transition to parenthood, and parenting school-aged daughters. The final paper focuses on a demand-side factor potentially impacting the gender pay gap, motivated by recent changes in labour markets due to technological advancements.

The research questions and contexts for each paper were chosen independently from each other. Each paper is based on different datasets, using the best available data for the respective research question. The papers are written with a social science audience in mind. They use econometric methods and are motivated by the economics literature discussed in Section 1.1. Given the interdisciplinary nature of the topics, I also draw on literature from the fields of sociology and social psychology.

The terms gender role attitudes and gender (social) norms are used throughout the thesis and are therefore defined here.[3] Gender norms and gender roles in this thesis refer to the appropriate roles of men and women concerning the gender division of work and the consequences of parental labour force participation for children's wellbeing. I use the definition of gender norms from Pearse & Connell (2016), who define them as "collective definitions of socially approved conduct [...] applied to groups constituted in the gender order - mainly, to distinctions between men and women" (p. 31). Hence, norms signal to other members of a group or society how they should behave (Schwartz 2012). Similarly, psychologist Alice Eagly uses the term 'injunctive norms' to speak about "consensual expectations about what a group of people ought to do or ideally would do" (Eagly & Karau 2002, p. 574). The concept of gender norms is related but different to that of stereotypes, understood as 'consensual expectations about what members of a group actually do' (Eagly and Karau, 2002), or gender ideologies, used to 'justify the gender imbalance in power and resources' (Seguino 2007).

By attitudes I understand evaluations of behaviour or people as good or bad; they vary on a positive/negative scale and can be expressed by statements such as 'I like/dislike'or 'I agree with/disagree with' (Schwartz 2012, Bicchieri 2017). Therefore, attitudes towards gender roles are individual evaluations of these gender roles and norms; and a positive attitude would reflect an endorsement of the collective gender norm in the society. Gender role attitudes encompass beliefs about "the assignment of different adult social responsibilities to men and women" (Pleck 1977, p.182). I use the terms 'attitudes towards gender roles' and 'attitudes towards

[3]These definitions are the same as the ones that appear in the published version of Chapter 4.

gender norms' interchangeably.

I distinguish between the terms gender and sex throughout the thesis. I follow the definitions by Eckert & McConnell-Ginet (2013) who state that "sex is a biological categorization based primarily on reproductive potential, whereas gender is the social elaboration of biological sex. [...] Gender builds on biological sex, but it exaggerates biological difference, and it carries biological difference into domains in which it is completely irrelevant. There is no biological reason, for example, why women should mince and men should swagger, or why women should have red toenails and men should not" (p. 2). Gender is therefore a social construct and "refers to the attitudes, feelings, and behaviors that a given culture associates with a person's biological sex" (APA 2021).

While I acknowledge that the appropriate use of terminology can be context-specific and the distinction is not always clear-cut (as reflected in the evolving and differing use of terms among different fields and scholars)[4], I follow the recommendations set out in APA (2021) by using the term gender when referring to people as social groups, and using the term sex when the biological distinction of sex assignment is predominant. As the focus of my thesis is on advancing the understanding of factors related to the inequality between women and men in the labour market that are socially constructed rather than biological, this is reflected in my predominant use of the term gender compared to sex. To give a few specific examples, I use the terms gender pay gap, gender division of labour, gender differences in occupations, gender differences in the labour market, gender roles, gender norms, and gender-typical choices, and I use the terms occupational sex segregation, sibling sex, same-sex parent, and sex composition within an occupation. I thereby follow the practice of several sociologists, economists and gender scholars (see e.g. Charles & Bradley 2009, Eckert & McConnell-Ginet 2013, Gangl & Ziefle 2015, Blau & Kahn

[4]See also Eckert & McConnell-Ginet (2013, p.2): "while we think of sex as biological and gender as social, this distinction is not clear-cut. People tend to think of gender as the result of nurture – as social and hence fluid – while sex is the result of nature, simply given by biology. However, nature and nurture intertwine, and there is no obvious point at which sex leaves off and gender begins".

2017).

1.3 Thesis outline

The remainder of the thesis consists of four empirical papers associated with the issues and motivations set out above, and a conclusion chapter that summarises the findings and discusses common limitations, implications, and areas for future research. The second Chapter explores the role of intergenerational transmission for gendered university major choices of young adults. The third Chapter estimates the impact of a parental leave policy reform on parents' attitudes towards gender roles. The fourth Chapter studies whether parenting daughters, as opposed to sons, changes parental attitudes towards the gender division of work. The fifth Chapter analyses the impact of industrial robots, a specific type of automation, on the gender gap in earnings.

In Chapter 2, I explore the role of intergenerational transmission for gendered university major choices of young adults in Germany. Major choices have immediate consequences on occupational segregation and wage gaps (Ponthieux & Meurs 2015). Motivated by this observation, I study to what extent and why gender-typicality of parents' occupation affect the gender-typicality of the university major their adult children choose. Using regression analysis and survey data from a recent cohort of university students in Germany, I examine the association between gender-typicality of mothers' and fathers' occupation and gender-typicality of their children's university major.

Results reveal significant associations between the gender-typicality in parents' occupations and their children's majors. This is especially evident in sons choosing less typically male majors if, when growing up, their fathers worked in less typically male occupations. Results point to two underlying transmission channels: the transfer of occupation-specific resources and the transmission of gender roles. The paper highlights the relevance of parental resources and parental socialisation for gendered university major choices.

Parenthood is often the starting point of persistent gender inequalities in earnings (Budig & Hodges 2010, Kleven et al. 2019). This is partly because the behaviour of parents is rooted in traditional gender norms and beliefs about the appropriate roles of men and women concerning the gender division of responsibilities (Aisenbrey et al. 2009, Schober 2013). Therefore, Chapters 3 and 4 study whether external events and experiences affect such traditional attitudes towards gender roles in the context of parenthood.

Parental leave policy, which can provide incentives concerning the gender division of paid and unpaid work in the early years of parenthood, plays an important role. However, in order to achieve behavioural changes, policy reforms need to be accompanied by attitudinal changes (Farré 2016). Therefore, Chapter 3 analyses effects of the 2007 paid parental leave reform (Elterngeld) in Germany on parents' gender role attitudes; specifically, attitudes towards the gender division of work, towards fathers' roles, and towards the consequences of mothers' labour force participation for child wellbeing. The policy reform intended to increase fathers' involvement in childcare and to speed up mothers' return to work after childbirth.

I find that the reform increased support for traditional gender roles for fathers among parents affected by the reform, compared to parents before the reform. I find no effect on the other two outcomes: attitudes towards the gender division of work, and attitudes towards the consequences of mothers' labour force participation. I also find that the reform did not impact the sharing of household and childcare activities.

Focusing on the UK, Chapter 4, jointly written with Mireia Borrell-Porta and Joan Costa-Font, also studies the impressionability of parental gender role attitudes. Specifically, the paper explores whether parenting daughters affects attitudes towards the traditional male breadwinner norm in which it is the husband's role to work and the wife's to stay at home. The paper is motivated by the broader question of whether gender role attitudes are stable over the life course of an individual or whether parenting daughters – as opposed to sons – changes them.

Using panel data and individual fixed effects models, the results show that fathers

are less likely to hold traditional views on the gender division of work if they raise a girl. We find no robust effects on mothers' attitudes. We conclude that gender role attitudes are not stable throughout the life-course and can be significantly shaped by adulthood experiences.

Chapter 5, jointly written with Cevat Giray Aksoy and Berkay Özcan, studies whether technological change increases gender inequality. Despite the fact that automation is one of the most profound changes that labour markets are facing, there is strikingly little empirical research on how automation might affect gender equality. Motivated by this gap, the paper studies the impact of industrial robots, a specific type of automation, on the gender pay gap. Using individual-level data from around 28 million individuals in 20 European countries, the paper provides the first large-scale evidence on the impact of industrial robots on the gender pay gap.

Using an instrumental variable strategy, findings indicate that robot adoption increases both male and female earnings but also increases the gender pay gap. These results are driven by countries with high initial levels of gender inequality and can be explained by the fact that men at medium- and high-skilled occupations disproportionately benefit from robotization, through a productivity effect.

In the final Chapter of the thesis (Chapter 6), I summarise the findings and contributions of each of the four empirical papers. I also discuss policy implications, limitations, common threads that emerge from taking the findings of the papers together, and useful directions for future research.

Chapter 2

Gendered university major choice: The role of intergenerational transmission

Abstract

In this paper, I study to what extent and why the degree of femininity of mothers' occupation and the degree of masculinity of fathers' occupation affect whether their adult children choose typically male or female majors at university. To do so, I introduce a novel measure to operationalise the extent to which majors and occupations are 'typically female' or 'typically male' and I use data on a recent cohort of university students in Germany. Results reveal that sons choose less typically male majors if their fathers worked in less typically male occupations. Moreover, the major choices of sons are not associated with their mothers' occupation. On the other hand, daughters choose more typically female majors if their fathers worked in less typically male occupations and if their mothers worked in more typically female majors. The mother-daughter correlation is observed only if mothers possess tertiary education, while fathers' occupation is significantly associated with children's choices independently of their educational level. As to why these effects occur, results support the transfer of occupation-specific skills, resources, and networks from parents to their children. The results also suggest that at least some of the father-son associations are due to a transmission of gender roles.[1]

[1]Note on data used: This chapter uses data from the National Educational Panel Study (NEPS): Starting Cohort First-Year Students, doi:10.5157/NEPS:SC5:14.0.0. as well as Starting Cohort Grade 9, doi:10.5157/NEPS:SC4:10.0.0. From 2008 to 2013, NEPS data was collected as part of the Framework Program for the Promotion of Empirical Educational Research funded by the German Federal Ministry of Education and Research (BMBF). As of 2014, NEPS is carried out

2.1 Introduction

Gender differences in the labour market persist, despite narrowing gaps between men and women in labour force participation, earnings, and occupations since the mid-twentieth century. The gender earnings gap in particular has received increased attention over the past decade. One fact emerging from research is that the gender gap in earnings tends to be wider among university graduates, compared to those with lower education levels (Goldin et al. 2017, OECD 2020).

Existing literature suggests that an important part of the gender pay gap among university graduates stems from choices made earlier in the life course. That is, gender differences in university majors (Brown & Corcoran 1997, Charles & Bradley 2002, Machin & Puhani 2003, Black et al. 2008). Men are more likely than women to study STEM (science, technology, engineering, mathematics) fields. Women are overrepresented in humanities, social sciences, and educational sciences (Leuze & Strauß 2009).

Women are more likely to choose majors that typically lead to occupations with lower earnings and fewer opportunities for career progression (Charles & Bradley 2002, Blau & Kahn 2017). Gendered major choices thus have direct consequences on occupational segregation, on wage gaps, and on so-called glass ceilings - the idea that there are invisible barriers that prevent women from achieving top incomes and positions (Ponthieux & Meurs 2015, Bertrand 2018). Sex segregation by university major also has important indirect consequences. For example, it may reinforce existing gender norms and stereotypes, thereby limiting the perceived educational choices of future generations (Charles & Bradley 2009).

Most research seeking to explain the determinants of gendered major choices privileges one of two types of factors. Some show the relevance of individual-level characteristics. These include personality traits such as competitiveness, beliefs about enjoying coursework, and preferences over expected jobs (Antecol & Cobb-Clark 2013, Zafar 2013). Others focus on the role of the social environment such as

by the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg in cooperation with a nationwide network.

teacher role models or sex of high school peers (Carrell et al. 2010, Brenoe & Zoelitz 2019). However, few studies have investigated the role of parents in shaping the choice of university major (e.g. Humlum et al. 2018, Vleuten et al. 2018). This is despite the fact that parents transmit occupation-specific resources to their children (Vleuten et al. 2018). Moreover, children observe and learn from the gender roles enacted by their parents (Crouter et al. 1995, Platt & Polavieja 2016). For example, children learn about the degree to which their parents follow traditional gender roles by observing their occupations (Polavieja & Platt 2014). This is because occupations differ in the degree to which they are regarded as typically female or typically male.

The aim of this paper is to analyse whether the degree of femininity of mothers' occupation and the degree of masculinity of fathers' occupation affect whether their adult children choose gender-typical majors at university and to study underlying transmission channels, using Germany as a case study. Specifically, I distinguish between the transmission of occupation-specific parental resources from the transmission of gender norms. To capture the degree to which a mother's occupation is regarded as typically female, I construct a rank-based measure based on the share of women in the occupation she held when her child was aged 15. I call this measure 'femininity rank of mothers' occupation' or 'mothers' rank'. Similarly, I construct masculinity rank in fathers' occupations (fathers' rank), masculinity rank in sons' majors (sons' rank), and femininity rank in daughters' majors (daughters' rank). I use the term 'gender-typicality rank' to refer to masculinity and femininity rank at the same time. Similarly, I use 'gender-typical' when referring to typically male and typically female majors simultaneously.

I exploit unique survey data of a nationally representative cohort of first-year undergraduate students in Germany in 2010. Using regression analysis, I examine the association between femininity rank of mothers' occupation and masculinity rank of fathers' occupation on the one hand and the gender-typicality rank of young adults' university majors on the other hand. I thereby capture intergenerational positional changes in each person's position relative to others of the same cohort and sex.

Germany is an important case study because its labour market exhibits low occupational mobility. This means that initial major choices at university have long-lasting effects on career outcomes, such as lifetime earnings (Aisenbrey & Brückner 2008). Moreover, the gender pay gap in Germany is particularly high among university graduates. In 2006, women with Abitur (school-leaving certificate) and a vocational qualification earned 38 percent less than equally qualified men, while tertiary-educated women earned 42 percent less than men with comparable qualifications (OECD 2008*a*).

I find that sons choose less typically male majors if their fathers worked in less typically male occupations, as measured by their respective 'masculinity rank'. Sons' choice is not correlated with their mother's occupation. Daughters choose more typically female majors if their fathers worked in less typically male occupations and if their mothers worked in more typically female occupations. While the father-son and father-daughter associations hold generally, the mother-daughter association is statistically significant only under certain conditions: if mothers possess tertiary education, if mothers were in employment, and among those living in East Germany. Moreover, results from quantile regressions and heterogeneity analyses show that the significant effects appear to be driven by parents and students in less gender-typical occupations and university majors, suggesting that fathers in gender-atypical occupations can help break gender stereotypes and that the findings of the paper are at least partially driven by sons and daughters who defy gender-stereotypical major choices. In terms of effect size, a one standard deviation increase in masculinity rank in fathers' occupation is associated with a 3 percent decrease in daughters' femininity rank and a 5 percent increase in sons' masculinity rank in major.

As to why these effects[2] occur, a large part of the results appears to be driven by children choosing a major that is closely related to parental occupation. This supports a 'direct transfer of resources' channel, that is, the transfer of occupation-specific skills, resources, and networks from parents to their children. The results

[2]I use the verbs 'associated with' or 'correlated with' when describing regression results in this paper as the results cannot be interpreted as causal effects. I use the noun effect in a non-causal way throughout the paper.

also suggest that at least some of the father-son associations are due to a transmission of gender roles.

The findings from this study have important implications. First, the relevance of parental socialisation points to the importance of policies that address early roots of gendered major choices. Second, the interactive effect of parental education with masculinity/femininity in parental occupation implies that role models are important and that their status may matter more than their sex for young people to identify with them. Third, the finding that intergenerational transmission is strongest between fathers and sons points to a need for policy to focus on men (and not predominantly on women) when attempting to tackle sex segregation in the labour market. While it is important to encourage women to enter highly paid STEM fields, policy should also aim at changing men's attitudes and encouraging them to enter traditionally female-dominated fields. The finding that sones with fathers in less gender-typical occupations choose less typically male university majors is therefore encouraging.

I make three contributions to existing literature. First, the paper improves the understanding of gendered major choices by providing the first analysis on the role of gender-typicality of parental occupation in Germany. Second, I introduce a new rank-based measure, which is used in research on intergenerational income mobility (Chetty et al. 2014), but has not been applied to gendered occupational and major choices. This is unfortunate because previously used measures, based on the share of women in an occupation/major, are affected by changes in the sex composition of the workforce as a whole. Instead, rank measures capture positional mobility between parents and their children, whereby each person's position is relative to others of the same cohort and sex. Finally, I am able to distinguish between two different transmission channels, by disentangling the transmission of parental resources from that of gender norms. I thereby contribute to the literature on the intergenerational transmission of gender norms, which mainly draws evidence from intergenerational associations in female labour force participation and does not allow for such a distinction. Identifying transmission channels is important for the design of effective

policies to address sex segregation in university majors.

The remainder of the paper is organised as follows. Section 2.2 reviews existing evidence on the determinants of gender differences in university major choice, and describes how university major choice operates in Germany. Section 2.3 presents the data and methods. Section 2.4 reports the results, Section 2.5 studies transmission channels, and the last section concludes.

2.2 Gender differences in university major

2.2.1 Determinants of gender differences in major choices

University major choice is complex and influenced by many factors, including expected earnings, perceived own ability, and exposure to a given major, among others (see Altonji et al. 2016 for a recent review). A subset of this literature studies the drivers behind gender differences in major choices. Empirical research interested in the determinants of gendered major choices tends to focus on one of two types of factors.

Some argue that individual-level factors determine gendered major choices. For example, research has shown that gender differences in personality traits such as competitiveness, beliefs about enjoying coursework, and preferences over expected jobs all contribute to the gender gap in majors (Antecol & Cobb-Clark 2013, Zafar 2013). While important, these papers ignore that gendered preferences and self-conceptions are a result of gender socialisation processes (Cech 2013).

Other research studies the role of the social environment for the probability to choose specific groups of majors. This strand of research shows that the social environment directly affects gendered major choices in many cases. For example, a recent paper finds that a higher proportion of female high school peers reduces women's probability and increases men's probability to choose a STEM major (Brenoe & Zoelitz 2019). Having female teachers increases women's likelihood to choose a STEM degree (Carrell et al. 2010, Bottia et al. 2015). And having a sister increases

men's likelihood to study Economics, Business, or Engineering (Anelli & Peri 2015).

While important in its own right, using STEM as an outcome measure when studying gendered university major choices more broadly has several shortcomings. First, there is substantial within-group heterogeneity in sex composition within STEM majors and other broad groups of majors. This constitutes a shortcoming for those interested in the factors underlying the persistent gender differences in major choices. Moreover, a binary STEM measure tends to put strong emphasis on the lack of women in STEM fields while ignoring the underrepresentation of men in certain other fields as the flip side of gendered choices. To overcome these shortcomings, I introduce a novel measure of gender-typicality, which I describe in section 2.3.

Although the family is a key agent of primary socialisation (Bandura 1977), only few papers study the role of parental transmission for gendered major choices. In particular, there is not much evidence on the importance of parents' occupation and specifically the degree to which these occupations are typically male or female. Two recent studies address this gap by analysing the association between share of women in parents' occupation or educational field and share of women in offspring's educational field, with different results. A study in Denmark finds a positive association between the female share in the education of mothers and the female share in the major of their daughters, as well as between the female share in the education of fathers and that of their sons (Humlum et al. 2018). A related paper studying field of study choice at secondary education level in the Netherlands also finds a positive relationship between the female share in mothers' occupation and in daughters' field of study (Vleuten et al. 2018). However, there is no father-son correlation. Instead, mothers employed in more female occupational fields are more likely to have sons in more male-dominated fields.

These papers use the sex composition to identify the degree to which a major is gendered. While this is a useful measure, it warrants further improvement. I build on this small set of literature by introducing a rank-based measure of the degree to which an occupation or major is typically male or female. This measure is described

in more detail in section 2.3.

2.2.2 Channels of intergenerational transmission

Socialisation theories in sociology (e.g. Eagly 1987, Okamoto & England 1999) and in social psychology (e.g. Bandura 1977) argue that parents act as key agents of socialisation to their children. Gender socialisation theories suggest that children specifically emulate the behaviour of the same-sex parent (Vleuten et al. 2018). Gendered behaviours can either result from children observing the behaviour of their same-sex parent and actively choosing to imitate them (cognitive developmental theory; Kohlberg 1966), or because parents encourage them to adhere to gender roles (social learning theory; Bandura 1977). Therefore, from an early age, children form beliefs about what constitute culturally appropriate behaviours and preferences for girls and boys, including appropriate types of jobs.[3]

In economics, cultural transmission and socialisation processes have been incorporated into economic models since the start of this century (e.g. Akerlof & Kranton 2000, Alesina & Giuliano 2015, Bisin & Verdier 2001, 2011, Escriche 2007). Within this literature strand, a number of empirical studies have tried to identify the existence of gender social norms through the study of female labour supply decisions. For example, Fernández & Fogli (2009) demonstrate that second-generation immigrant American women whose ancestry is from countries with higher female labour force participation work more. Olivetti et al. (2020) show that a woman's labour supply in early adulthood is affected by the labour force participation of past high school peers' mothers. These correlations in labour force participation are interpreted as evidence of the existence and intergenerational transmission of gender norms. However, a key shortcoming of this empirical research is that it is not possible to distinguish whether the intergenerational associations in labour force

[3]Evidence suggests that as early as in second grade, children think that maths is for boys and not for girls (Cvencek et al. 2011). Gender socialisation even affects school performance. For example, a significant part of the gender gap in maths test scores in secondary school can be attributed to the transmission of cultural beliefs concerning gender roles (Nollenberger et al. 2016). Moreover, compared to boys, girls aspire to occupations that have a higher share of women and pay less (Polavieja & Platt 2014, Platt & Parsons 2017).

participation are due to a transmission of gender norms or due to other reasons such as a transfer of resources or imitation.

I address this limitation and contribute to this strand of literature by studying a different outcome, university major, which allows me to distinguish between the relative importance of two transmission channels: the gender-typicality *per se* and the transfer of occupation-specific resources. This is possible because occupations and university majors can be classified along two dimensions - their broad field as well as their gender-typicality. This distinction is not possible when studying female labour supply decisions.

More specifically, two main channels can account for intergenerational associations between gender-typicality rank in parents' occupation and rank in offsprings' major: a direct transfer of resources on the one hand and a transmission of gender roles or gender norms on the other hand (Vleuten et al. 2018).

A direct transfer of resources takes place when young adults choose a major that is similar to their parents' occupational field. This encompasses what is commonly referred to as the transfer of occupation-specific human capital (e.g. Humlum et al. 2018) and the inheritability of parental endowments (e.g. Becker & Tomes 1979) in economics, and the transfer of occupation-specific resources within sociology (e.g. Jonsson et al. 2009). Taking a broad definition, this channel includes the transfer of occupation-specific and financial resources, social networks, human capital, traits, and abilities (Vleuten et al. 2018, Aina & Nicoletti 2018). It occurs, for example, if the child whose parent is a doctor studies medicine. Each occupation and each major differs in the degree to which it is gendered. Consequently, direct transfer mechanically leads to positive intergenerational associations between parents and children's femininity or masculinity rank in occupation and major, respectively. It is reasonable to assume that young adults are more likely to identify with and use the resources of the more influential parent whose social position dominates that of their spouse (Dryler 1998), for example in terms of occupational status, income, or educational level.

A second, 'indirect channel' is present if children choose majors that are unrelated

to their parents' occupations but we still observe a significant association between gender-typicality in parental occupation and gender-typicality in children's majors. The presence of an indirect channel can be interpreted as strong evidence for gender socialisation and the transmission of gender norms. This is because the possibility of a direct transfer is very limited and instead the gender-typicality rank *per se* matters for gendered major choices. Empirically, this can be tested by studying heterogeneous effects across those children who choose majors that are related to the same field as their parents' occupations and those whose majors are unrelated to parents' occupations.

These two competing transmission channels are interrelated and cannot be considered completely independent, both from a theoretical as well as from an empirical perspective. From a theoretical perspective, parents may be more likely to transmit occupation-specific resources to their children if these are in line with cultural gender norms. For example, fathers in STEM occupations are found to transmit their occupation-specific preferences to their daughters only in the absence of a son (Oguzoglu & Ozbeklik 2016). From an empirical perspective, it is possible that a transmission of gender roles occurs *within* groups of students who choose majors closely related to their parents' occupation. In other words, there may still be a transmission of gender norms even if we do not find empirical evidence for the 'indirect' transmission channel. In light of these considerations, empirical evidence of the existence of the 'indirect' transmission channel therefore provides an even stronger case for the existence of gender norms.

There is little empirical research that has tried to disentangle these transmission channels and identify the existence of gender norms in the context of gendered university major choices (but see e.g. Humlum et al. 2018). Studies on related but different outcomes such as occupational choices, occupational aspirations, and field of study choices in secondary school have produced mixed results. While some studies find support for a transmission of gender roles (e.g. Polavieja & Platt 2014, Vleuten et al. 2018), others find no such support (e.g. Dryler 1998).

2.2.3 Major choice in tertiary education in Germany

In 2010, 49 percent of secondary school graduates obtained a school-leaving certificate qualifying them for tertiary education. Of those, 69 percent obtained Abitur (Allgemeine Hochschulreife) and the rest obtained a subject-linked school-leaving certificate (Brugger et al. 2012). Abitur is a school-leaving certificate obtained at the end of upper secondary education for students who attend the 'highest' Gymnasium school track.[4] In principle, this certificate provides eligibility to study any major at any university. In contrast, subject-linked school-leaving certificates (Fachhochschulreife or fachgebundene Hochschulreife) restrict eligibility either to certain majors or to university of applied sciences (Fachhochschulen). In addition to qualifying for entry to university via a school-leaving certificate, a small share of students enters university education via a 'non-traditional' route without a school-leaving certificate. These students qualify through other criteria such as vocational training (Neugebauer & Schindler 2012). The entry rate into tertiary education in 2010 was 45 percent (Brugger et al. 2012).

When applying for an undergraduate degree, students choose a major (Studienfach), such as mathematics, German studies, or mechanical engineering. Students also take two additional decisions particular to the German tertiary education system. First, they choose one of two main types of tertiary education institutions, traditional research universities (Universitaeten) and universities of applied sciences (Fachhochschulen). While universities offer degrees in all majors, universities of applied sciences have a more applied focus and offer a limited range of applied sciences majors (Jacob & Weiss 2010). Second, with many majors, a student can choose between graduating with a 'regular' undergraduate degree or with a 'teaching' degree. The latter type is necessary to become a school teacher.

Therefore, in studying major choices I distinguish between 58 majors as well as the three mutually exclusive 'types' of degree, namely university, university of

[4] Access to tertiary education in Germany is characterised by high social inequality, which is partly due to an early tracking into different school types in lower secondary school. Students with parents who possess tertiary education are much more likely to attend the highest school track (Gymnasium) at lower secondary school (Müller & Schneider 2013).

applied sciences, and teaching degree. Since not all 58 majors are available for each of the three degree types, their combination yields 134 distinct categories. Figure 2.A.1 in Appendix 2.A shows the sex composition for the 30 most common categories. The graph reveals that major choices are strongly gendered.

Choosing a university major is an important decision because the German labour market has strong linkages between majors and occupations (Leuze 2007). In fact, the German labour market is known "as a prototypical case of an occupational labour market where job applicants are matched to jobs according to their occupation-specific credentials" (Klein 2016, p. 46). Around three quarters of the gender differences in earnings at job market entry of graduates can be explained by gender differences in university major (Braakmann 2008). Moreover, low occupational mobility means that initial major choices at university have long-lasting effects on career outcomes, such as lifetime earnings (Aisenbrey & Brückner 2008).

University major choice in Germany is not only an important decision from the individual's perspective, but its study also has a number of advantages compared to studying related choices such as the one of occupation. While gender differences in university majors and in occupations are closely related, the choice of a major is less influenced by demand factors than the choice of an occupation. Determinants of occupational segregation include supply side factors such as individual preferences as well as demand side factors such as gender stereotypes of employers enacted when employers select job candidates (Hausmann & Kleinert 2014) and current labour market conditions. Compared to that, major choice allows a focus on supply side factors and is therefore a closer reflection of individual preferences.

One concern is that major choices may not adequately reflect people's preferences because many majors have admission restrictions to manage high demand. In this paper's sample, 70 percent of students entered a programme with admission restrictions, with the high school GPA (Abiturnote) being the most important and often sole criterion. This means that only students who graduate with a GPA above a certain threshold (called numerus clausus) are admitted to the programme. This means that on the other hand 30 percent of programmes have no admission

restrictions, that is, students with a school-leaving certificate can enrol directly at the respective university without the need to fulfil any additional requirements.

To alleviate part of the concern that major choice may not adequately reflect individuals' preferences, in Section 2.4 I conduct a robustness check on students who graduated with a GPA above the median and a robustness check on students who state that they entered their desired major. These restrictions do not change results. Furthermore, while not all students may be able to enter their preferred major, from a policy perspective, it can be argued that studying the actual choices students make given their constraints is more important than studying idealistic aspirations.

Literature on the determinants of university major choice in Germany suggests that social origin plays a role in university major choice. For example, individuals whose father possesses a tertiary degree are more likely to choose majors that are considered prestigious, such as medicine or law (e.g. Reimer & Pollak 2010, Georg & Bargel 2017). Apart from that, the choice of a university major is treated as largely self-determined in the literature. This is supported by evidence that intrinsic motives, in particular interest in the major, are an important factor for major choice while conformance with friends' and parents' expectations are found to be less important (Heine et al. 2008, Ochsenfeld 2016). Moreover, teacher recommendations or evaluations are not usually needed for entry to university and are not commonly included as an independent variable in regression models. In line with this, self-reported information from students indicates that the three most-used sources to inform major choice are the internet, friends, and information material provided by universities (Heine et al. 2008). On the other hand, much fewer students cite conversations with teachers as a source of information and only a fifth of those who name teachers as a source evaluate them as useful.

Additionally, a few characteristics of the tertiary education system make Germany a well-suited case to study major choices as a relatively 'free choice' that closely proxies individual preferences. First, the choice of major is not restricted by earlier field of study or track choices at secondary school. This is in contrast to

other countries such as the UK or Italy, where entry to some university majors is conditional on having taken certain exams or tracks in secondary school[5]. Second, in contrast to other countries such as the US, it is not possible to enter university without declaring a major. Therefore, the choice of major takes place (just) before a student enters university, at the time when he or she applies for a degree. Third, the high selectivity into certain prestigious universities in countries such as the UK or US does not exist in Germany. Instead, universities are considered more equal in quality and there is no strong hierarchy among universities (Jacob & Weiss 2010). Finally, university education in 2010 was free in most of the 16 federal states. Even in the five federal states that charged tuition fees in 2010, usually at EUR 500 per semester, they were relatively low in international comparison.

2.3 Data and methods

2.3.1 Data sources and sample

The main dataset used is the Starting Cohort 5 of the German National Educational Panel Study (NEPS-SC5, see Blossfeld & Roßbach 2011). The NEPS-SC5 contains rich data of a nationally representative cohort of 17,910 first-year undergraduate students who started their degree in October 2010, and who are enrolled for the first time in a public or state-approved higher education institution in Germany (see Zinn et al. 2017). Wave 1 interviews were conducted between December 2010 and January 2012 and to date, 9 waves of data are available, following individuals up until 2015. For the analysis, a cross-sectional dataset is constructed, using information from the wave 1 survey and from spell data on schooling.

The analysis sample is restricted to individuals between 18 and 25 years old who obtained Abitur (Allgemeine Hochschulreife). The age restriction allows for a focus on the transition from high school to university by excluding individuals who pursue

[5]For example, evidence from Italy shows that written teacher track recommendations are an important determinant of high school track choice and this track choice is strongly correlated with subsequent choice of university major (Carlana 2019).

a university degree as a second career later in life. The restriction to individuals with Abitur ensures that students are eligible for any degree at any type of university. However, robustness checks including individuals with other types of school-leaving certificates are shown in Section 2.4, and indicate that results remain substantially the same. I also drop observations with missing values on key variables.

Since information on parental characteristics is provided by students, this restriction implies that only individuals who know the educational level, age, and occupation of both parents are included. A parent is defined as the person who the student identifies with as mother or father. Therefore, I include controls for the family structure an individual grew up in, which distinguish between biological and adoptive parents on the one hand, and step and foster parents on the other hand.[6] I also run analyses on subsamples of different family structures, and the results do not change substantially. The final analysis sample consists of 9,640 individuals (6,100 female students and 3,540 male students).[7] Table 2.A.1 in Appendix 2.A shows how the different sample restrictions affect sample size and summary statistics. Overall, the changes in the mean values of key variables due to sample restriction are minimal.[8]

I use supplementary data from four sources. To construct the dependent variables, I use information on the total number of female and male students by university major and by degree type in Germany in the academic year 2010/11 from administrative data of the Federal Statistical Office (Statistisches Bundesamt 2011). For the key regressors, I use administrative data from the Federal Labour Office,

[6]The survey reports adoptive parents in the category of biological parents and groups step parents and foster parents.

[7]The initial full survey sample consists of 60 percent female students and the final analysis sample consists of 63 percent female students. The overrepresentation of women in the sample is primarily due to a higher survey response rate among women and to a lesser extent due to the exclusion of more observations on male students due to missing values on key covariates. The overrepresentation of female students is accounted for in the survey weights.

[8]There are two exceptions. The first is that when moving from the initial full sample to the one restricted to students who are aged 18 to 25 and hold a general school-leaving certificate, parents are more likely to have higher levels of education. This is expected because students with parents who possess tertiary education are more likely to attend the highest school track (Gymnasium) at lower secondary school (Müller & Schneider 2013). Moreover, the average rank in university major for men reduces from 55.3 to 52.5. Restricting the sample further by dropping observations with missing values on key variables does not change the mean values of any of the variables.

which contains information on occupational group of all female and male employees subject to social security contributions in Germany (Statistik der Bundesagentur für Arbeit 2014). The median income by occupational group is used as a control variable and is also obtained from the Federal Labour Office (Statistik der Bundesagentur für Arbeit 2018). The NEPS does not have good information on earnings. Therefore, estimates of average returns to major are obtained from the 2005 and 2009 DZHW Graduate Panel Survey (Brandt et al. 2018, Briedis et al. 2019), and used as a control variable in a robustness check. The DZHW Graduate Panel Survey is a four-yearly survey of higher education graduates administered by the German Centre for Higher Education Research and Science Studies (DZHW). It enables to study the transition of higher education graduate cohorts to professional careers. Finally, I use data from Starting Cohort 4 of the National Educational Panel Survey (NEPS-SC4) for a robustness check on the selectivity of the sample of university students in the main dataset NEPS-SC5. NEPS-SC4 is a nationally representative sample of students who were in grade 9 of compulsory education in the academic year 2010/11, who are followed throughout their subsequent school careers (Blossfeld & Roßbach 2011).

2.3.2 Methods

Before detailing the rank-based measures of gender-typicality in university major and occupation in the next subsection, I describe the regression model. The regression model resembles 'rank-rank' income regressions, which have been used in research on relative mobility in income (Chetty et al. 2014). The following baseline 'rank-rank' gender-typicality regression model, estimated via OLS, is used to study the association between gender-typicality rank of the occupation that mother and father held when the individual was aged 15 and the gender-typicality rank in daughters'/sons' university major:

$$R_i = \beta_0 + \beta_1 RM_i + \beta_2 RF_i + \beta_3 X_i + \beta_4 P_i + \delta_s + \varepsilon_i \tag{2.1}$$

where R_i is the gender-typicality rank of individual's university major, RM_i is the femininity rank of the occupation the mother held when the individual was aged 15, and RF_i is the masculinity rank of the occupation the father held when the individual was aged 15. X_i includes individual characteristics, namely seven age dummies, two birth order dummies, three dummies for family structure growing up, and a binary variable indicating 1st or 2nd generation immigrant. P_i are parental characteristics and include mothers' and fathers' age, a binary variable indicating the parent was employed when the individual was aged 15, three dummies for educational level, and controls for the median income in mothers' and fathers' occupational group, respectively. δ_s are federal state fixed effects. These variables are chosen to control, as good as possible, for variables that are correlated with both the gender-typicality rank in major and the gender-typicality rank in parental occupations. Summary statistics of all variables are reported in Appendix 2.A in Table 2.A.2.

The regression model captures intergenerational positional changes by identifying the correlation between parents' and children's position in their respective gender-typicality distribution, holding constant key parental and individual characteristics as well as federal state. All analyses are weighted using the cross-sectional sampling weights for wave 1, to account for the complex sampling design and for non-response (Zinn et al. 2017). Since parents' behaviour may affect sons' and daughters' choices in different ways, separate regressions are conducted for female and male students.

A key assumption of the regression model is that gender-typicality is linearly transmitted from parent's occupation to child's major. Yet it is possible that the transmission of gender-typicality occurs non-linearly or at certain points in the distribution only. For example, it may be that only fathers in occupations with a relatively low masculinity rank are associated with students' rank in major. Similarly, it may be possible that any associations hold only at certain points of the gender-typicality rank distribution of university majors. To explore these potential non-linearities, I therefore discuss results from quantile regressions and heterogeneous effects across the distribution of key regressors (subsection 2.4.3). Nevertheless, I argue in the next subsection that imposing linear transmission on rank-based measures possesses

advantages compared to the two approaches used in existing research. The first uses linear regressions with measures based on the share of women/men in occupations and majors. The second uses categorical regressors, which necessarily use arbitrary cutoffs of what constitutes a gender-typical occupation or major.

The analysis also suffers from a few data limitations. In particular, there is no information on parents' income or work hours, which would be useful to study relative parental status (e.g. relative income) in more detail. Moreover, sibling sex is not contained in the data, which has been identified as a relevant factor affecting gender-stereotypical behaviour (Anelli & Peri 2015).

2.3.3 Measures of gender-typicality in university major and in occupation

To measure the degree to which a university major is typically female, I rank each female student relative to the population of all female students in the academic year 2010/11 in Germany based on the share of women in her university major. I call this measure 'daughters' femininity percentile rank in university major', or 'daughters' rank' in short, and it takes values between 1 and 100. The femininity rank indicates a female student's relative position in the distribution of all female students, based on the share of women in their university major. For example, a woman enrolled in a psychology major at university is assigned a femininity rank of 85, indicating that 15 percent of female students are enrolled in a major with a higher share of women. Analogously, for male students, 'masculinity rank in university major' is constructed based on the student's relative position in the national distribution of all male students' share of men in university major.

Table 2.1 shows the 10 most common major choices for men and women, and their respective rank measure. Since each person's rank is based on the distribution of students of the same sex, the measures are sex-specific. For example, Table 2.1 shows that the femininity rank of an economics major at university is 21, while the masculinity rank of an economics major at university is 44.

Table 2.1: Most common majors/occupations and their rank

	Daughters' university major	Femininity rank	Sons' university major	Masculinity rank
1	Economics (FH)	31	Economics (Uni)	44
2	Economics (Uni)	21	Mechanical & process engineering (Uni)	84
3	Psychology (Uni)	85	Mechanical & process engineering (FH)	73
4	Law (Uni)	42	Economics (FH)	34
5	Human medicine (Uni)	56	Law (Uni)	24
6	Social sciences (Uni)	49	Computer science (FH)	78
7	German Studies (teaching)	90	Physics, astronomy (Uni)	68
8	Biology (Uni)	61	Industrial engineering & management, economics focus (FH)	60
9	Social sector (FH)	82	Industrial engineering & management economics focus (Uni)	61
10	German Studies (Uni)	78	Computer science (Uni)	89
	Mothers' occupation	Femininity rank	Fathers' occupation	Masculinity rank
1	Office administrator	39	Businessman/manager	43
2	Primary/lower secondary school teacher	59	Primary/lower secondary school teacher	4
3	Nurse/midwife	66	IT professional	50
4	Stenographer/typist	92	Doctor	27
5	Salesperson	56	Office administrator	12
6	Kindergarden teacher	94	Unskilled worker	36
7	Social worker/social care worker	62	Architect/construction engineer	42
8	Doctor's receptionist	99	Banking professional	19
9	Banking professional	22	Electrician	82
10	Doctor	13	Mechanical engineer	68

Sources: NEPS-SC5, author's calculations. Notes: Uni indicates university, FH (Fachhochschule) indicates university of applied sciences.

As mentioned in Section 2.2, university majors are distinguished not only by 58 fields of study but also by 3 different degree types, namely, teaching degree, university degree, and university of applied sciences degree. Their combination yields 134 distinct university majors, from which the femininity rank and masculinity rank measures are constructed. In cases in which students declare more than one major, I use the one they declare as their first major.

The key regressors are the femininity and masculinity percentile rank in the occupation of mothers and fathers, respectively. There are 334 distinct occupational groups based on the German occupational classification KldB88. Following the same logic as for the dependent variables, I construct a measure of the degree to which a mother's occupation is typically female. Specifically, I rank mothers based on the share of women in their occupation relative to all other employed women in Germany.[9] The 'femininity rank of mothers' occupation' or 'mothers' rank' takes

[9]The survey records the occupational group a parent held when the individual was aged 15. This

values between 1 and 100, and higher numbers indicate a more 'typically female' occupation. For example, the rank associated with a mother who is a kindergarden teacher is 94, indicating that 6 percent of mothers work in occupations with a higher female share. On the other hand, the rank associated with a mother who is a doctor is 13, suggesting that 87 percent of mothers work in occupations with a higher share of women. I also construct measures for a masculinity rank in fathers' occupations in an analogous way, ranking fathers based on the share of men in their occupation relative to all other employed men in Germany. By construction, the rank measures follow a uniform distribution with mean and median 50.[10]

Students report information on the occupation that their parents held when they were aged 15. Therefore, the measures capture the role of parental occupation during adolescence for students' gendered university major choices in early adulthood.[11] The ten most common occupations for mothers and fathers and their respective

allows studying the association between gender-typicality of parental occupation during adolescence for students' gendered university major choices in early adulthood. To construct rank measures for mothers' (fathers') occupations, I therefore use information on the female (male) share by occupational group corresponding to the year in which the individual was aged 15. Since the sample is restricted to individuals aged 18 to 25 in the year 2010, I use administrative data (Statistik der Bundesagentur für Arbeit 2014) on the female (male) share by occupational group for one of the years in the period between 2000 and 2007, depending on each individual's age. While the sex composition of individual occupations may have changed by 2010, using data from the year in which the individual was aged 15 best captures the degree of gender-typicality that the occupation represented when the individual was an adolescent.

[10]There are important differences in the gender-typicality of different occupations across different countries. Ideally, for the descendants of immigrants, I would therefore construct parental rank measures based on the sex composition of occupations in their home country at the time when the individual was aged 15. Unfortunately, this is not feasible given that country-specific occupational classifications used in different countries are not easily matched to the German KldB88 classification used in this paper. Moreover, while there is information on parental birth country, this is not necessarily the same as what the parent considers their home country. I therefore include a dummy taking a value of one for individuals who are first or second generation immigrants (based on recorded birth country) in all analyses, and I perform a robustness check excluding those individuals from the analysis (see Table 2.A.6).

[11]There may be concerns about the relevance of this measure if there is a high degree of occupational mobility among parents. However, I argue that the measure is appropriate for the purpose of this paper for several reasons: First, capturing parental occupation at age 15 is meaningful as the focus of this paper is studying the role of parental occupation during adolescence in the context of gender socialisation. Second, the German labour market is characterised by low occupational mobility (Aisenbrey & Brückner 2008). Third, the measure is based on 334 occupational groups, which aggregate 1,991 different occupations of similar nature. Therefore, if parents switch occupation to a closely related one of similar nature, this would be captured within the same occupational group.

rank are shown in Table 2.1.

The generation of parents studied in this paper often follows a traditional gender division of work. 17.6 percent of students' mothers in the sample are 'inactive', that is, they have not been employed since the student was born (as opposed to 0.9 percent of fathers) and have therefore no occupation recorded in the survey. However, excluding all these students from the analysis would lead to a highly biased sample, leaving out those who have parents with the most gender-traditional household allocation of work. Moreover, having an inactive mother has been shown to negatively affect daughters' labour force participation (e.g. Morrill & Morrill 2013). Similarly, prior research has shown that the relative income of mothers compared to fathers is related to the gender-typicality in sons' major choices (Humlum et al. 2018). While inactive mothers cannot transmit occupation-specific resources to their children, their inactivity gives signals about appropriate gender roles to children, which may translate into major choices.

Therefore, I create a fictitious profession corresponding to the parents who were not employed in the period from the birth of the individual and the individual reaching age 15. I calculate the gender-typicality rank based on the sex composition of this fictitious profession.[12] A robustness check performed in Section 2.4 shows that their exclusion does not substantially alter results. To test the possibility that growing up with a mother out of the labour force may directly affect students' university major choices, I perform a robustness check with a dummy for mother being inactive (see Table 2.A.7).

There are several advantages that these rank measures possess over alternative measures used in prior research. Previous studies have operationalised the degree to which occupations or majors are typically female by using the share of women as a measure (Humlum et al. 2018, Vleuten et al. 2018). Figure 2.1 illustrates how the female (male) share by major/occupation corresponds to the femininity (masculinity) rank. Share-based measures have two undesired properties.

[12]The femininity rank for inactive mothers is 82 and the masculinity rank for inactive fathers is 2.

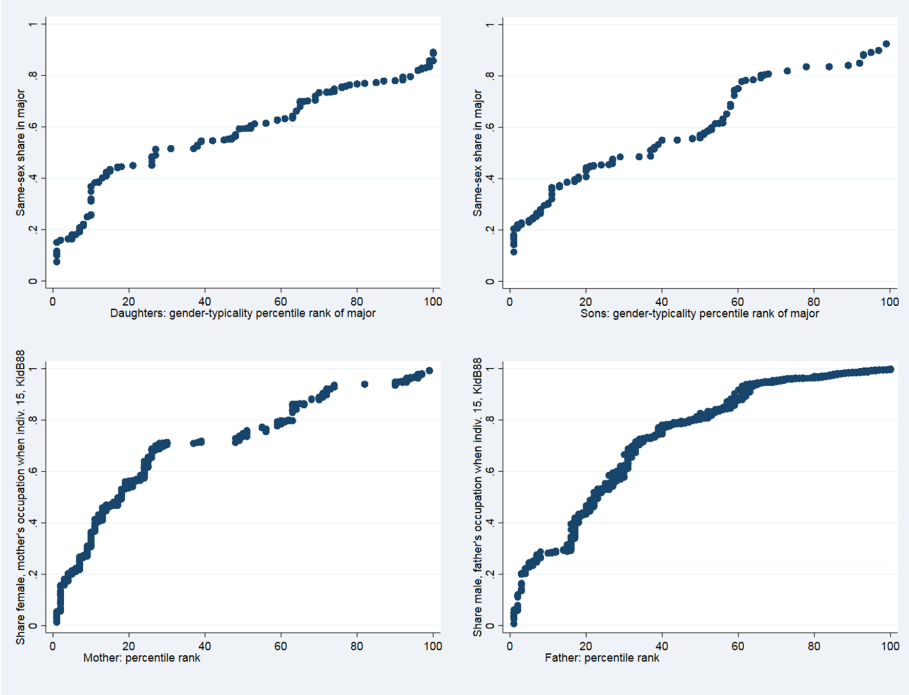

Figure 2.1: Scatterplot: share- vs. rank-based measures of gender-typicality

Source: NEPS-SC5.

First, the share of women within a given occupation may depend on the structure of occupational classifications. Specifically, the occupational classification KldB88 from the year 1988 reflects the occupational structures of the industrial society of the 1960s, with typically male occupations categorised into a higher number of smaller groups compared to female occupations (Hausmann & Kleinert 2014). If typically male occupations are systematically more detailed in occupational classifications than typically female ones, this may bias the sex composition within occupations. Specifically, it may partly explain why men tend to work in more segregated occupations while women bunch in a smaller number of occupations (Hausmann & Kleinert 2014). Moreover, the sex distribution of occupations is more dispersed than the distribution of university majors, partly due to the fact that the occupational classification is more detailed. Rank measures do not suffer from this problem because they capture the position of individuals relative to others of the same cohort and sex. A change in the sex composition of a university major affects the rank of

a student only insofar as it alters the student's position relative to the position of others.

Second and more importantly, the share of women in an occupation is affected by the sex composition of the workforce as a whole. That is, an increasing proportion of women within a certain occupation may be explained by an increase in female labour force participation, even if there is no change in the propensity of women or men to choose that particular occupation (England et al. 2007). Therefore, the fact that the overall female share among the 2010 university student population is higher than the female share among the total workforce in their parents' generation is reflected in share-based measures. This complicates a meaningful interpretation of share-based measures as measures of the concept 'gender-typicality' in a regression model as specified in equation 2.1. On the other hand, rank measures capture positional mobility between parents and their children, whereby each person's position is relative to others of the same sex and cohort. Therefore, coefficients from a rank-rank regression model as in equation 2.1 have a meaningful and straightforward interpretation. Specifically, coefficients can be interpreted as the association between a parent's relative position in their sex-specific occupational rank distribution and a student's relative position in their sex-specific university major rank distribution.

Occupations and university majors are also commonly categorised into 'male-dominated' and 'female-dominated' ones. For example, majors (or occupations) with a female share of 70 percent or above are often referred to as female-dominated, while those with a female share below 30 percent are labelled as male-dominated (e.g. Hausmann & Kleinert 2014). A key disadvantage of such categorisation is that these cutoffs are arbitrary. This is especially problematic in regression analysis because coefficients on binary or categorical regressors are interpreted relative to a baseline category. Changing the cutoff then also necessarily changes the baseline. For example, there is no theoretical reason for why estimating the effect of being in an occupation with a female share of 70 percent or above (compared to the baseline category of being in an occupation with a female share of less than 70

percent) is more meaningful than, for example, estimating the effect of being in an occupation with a female share of 66.67 (two thirds) percent (compared to being in an occupation with a female share below 66.67 percent). A second key disadvantage of categorical regressors, at least in the context of this paper's focus, is that a categorisation, independent of which cutoffs are chosen, implies a substantial loss of information regarding the degree of gender-typicality of occupations.

In sum, rank measures have the advantage that they are independent of the structure of occupational/major classifications and independent of the overall sex composition of the population. Therefore, estimating a linear relationship between parental and children's rank in their respective distribution has a straightforward interpretation. In the case of fathers and sons, for example, it captures the association between a sons' and a fathers' relative position in their respective distribution.

2.3.4 Summary statistics

The left part of Table 2.2 presents selected summary statistics for key variables, separately for sons and daughters. The average age of students is around 20 years, and their average rank in major approximately 51. As mentioned in Section 2.2, this is a sample of individuals who enter university and hence their parents are disproportionately highly educated. Therefore, in order to check the degree of selectivity, summary statistics are compared to those of NEPS-Starting cohort 4, a sample of grade 9 students which includes the full population of students in regular schools. These are reported in the right part of Table 2.2. The age difference between mothers and fathers of the two cohorts corresponds approximately to the age difference of the students across the two cohorts. Moreover, the share of mothers who were not in employment since the student was born is similar across both cohorts. Not surprisingly, the share of tertiary educated mothers and fathers in the undergraduate student cohort (SC5) is much higher compared to the average parent in the cohort of compulsory schooling grade 9 pupils (SC4). This is in line with previous research which shows that intergenerational educational mobility is low in Germany

(Heineck & Riphahn 2009).

Table 2.2: Selected summary statistics, comparison SC5 and SC4

	Starting cohort 5				Starting cohort 4			
	Sons		Daughters		Sons		Daughters	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Rank in major	51.6	24.4	51.2	31.3				
Age	20.5	1.2	20.2	1.5	14.8	0.6	14.8	0.7
Rank mother's occupation	53.4	25.9	53.1	32.1	52.5	27	49	30.5
Rank father's occupation	42.8	23.6	43.2	29.3	53.9	28.1	55.3	31.2
Mother inactive	0.19		0.17		0.18		0.16	
Mother's age	49.3	4.4	49.2	5.4	43.9	5.5	43.4	5.5
Father's age	52.1	5.2	51.9	6.4	46.5	5.5	46.2	6
Mother: tertiary education	0.31		0.3		0.08		0.1	
Father: tertiary education	0.44		0.42		0.12		0.09	

Notes: Survey weights used. Mother inactive indicates that mother was not in employed in the time period between the child's birth and the child reaching age 15. Sources: NEPS-SC4 and NEPS-SC5.

By construction, the rank measures have a mean of 50 if they are nationally representative. However, the highly educated parents of the study sample are not nationally representative. Indeed, the femininity rank in mothers' occupation is slightly higher in the cohort of university students, while fathers' rank is over 10 percentile points lower compared to starting cohort 4. This suggests that high-skilled mothers' occupations are more gender-typed while high-skilled fathers' occupations are less gender-typed compared to lower-skilled occupations. This can partly be explained by the fact that many occupations with a very high share of men, such as carpenters, truck drivers, and electricians, do not require tertiary education. A full set of summary statistics are reported in Appendix 2.A in Table 2.A.2.

2.4 Results

2.4.1 Main results

Panel A of Table 2.3 presents the main results on the relationship between gender-typicality rank in parental occupation and masculinity rank in university major for sons. Columns 1 to 3 do not include any controls or fixed effects. Column 1 considers femininity rank in mothers' occupation only, while column 2 includes masculinity

Table 2.3: Baseline rank-rank regressions estimated via OLS

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Subsample of sons. Dependent variable: Masculinity rank son's major						
Rank mother's occup.	0.0192		0.0190	0.0112	-0.0027	-0.0125
	(0.0155)		(0.0157)	(0.0141)	(0.0148)	(0.0160)
Rank father's occup.		0.1226***	0.1226***	0.1260***	0.1070***	0.1129***
		(0.0210)	(0.0209)	(0.0193)	(0.0190)	(0.0195)
Mother interm. schooling					0.7077	0.6125
					(1.4142)	(1.4064)
Mother high school					0.5955	0.5568
					(1.6223)	(1.5909)
Mother tertiary degree					-2.1632	-2.2416
					(1.5710)	(1.5490)
Father interm. schooling					0.2406	0.3231
					(1.5991)	(1.6323)
Father high school					-2.6718	-2.4875
					(1.8445)	(1.8231)
Father tertiary degree					-1.1029	-0.8256
					(1.6224)	(1.6943)
Observations	3,540	3,540	3,540	3,540	3,540	3,540
R-squared	0.0004	0.0141	0.0145	0.0432	0.0473	0.0573
Panel B. Subsample of daughters. Dependent variable: Femininity rank daughter's major						
Rank mother's occup.	0.0176		0.0185	0.0115	0.0242	0.0258
	(0.0148)		(0.0148)	(0.0147)	(0.0160)	(0.0165)
Rank father's occup.		-0.0452**	-0.0456**	-0.0517***	-0.0540***	-0.0547***
		(0.0192)	(0.0191)	(0.0180)	(0.0182)	(0.0183)
Mother interm. schooling					1.7392	1.7473
					(1.2968)	(1.3004)
Mother high school					2.9125*	3.1032*
					(1.6489)	(1.6393)
Mother tertiary degree					3.3214**	3.4145**
					(1.6213)	(1.6192)
Father interm. schooling					-1.2377	-1.2547
					(1.2461)	(1.2490)
Father high school					-2.1357	-2.1735
					(1.4909)	(1.5084)
Father tertiary degree					-1.8790	-1.7104
					(1.2893)	(1.3144)
Observations	6,100	6,100	6,100	6,100	6,100	6,100
R-squared	0.0003	0.0018	0.0021	0.0289	0.0311	0.0344
State FE	no	no	no	yes	yes	yes
Parental characteristics	no	no	no	no	yes	yes
Individual characteristics	no	no	no	no	no	yes
Parental income	no	no	no	no	no	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the masculinity/femininity percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively) . Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

rank in fathers' occupation only. The coefficient on mothers' rank in column 1 is positive but not statistically significant. In contrast, column 2 reveals a positive relationship between the degree to which fathers' occupation is typically masculine and the degree to which sons' major is typically masculine. A 1 percentile (i.e. 1 unit in masculinity percentile rank) increase in fathers' rank is associated with a 0.12 percentile increase in sons' rank. Column 3 jointly includes mothers' and fathers' rank, and the coefficients stay almost identical. This suggests that fathers' rank is independently associated with sons' rank and that assortative mating is not driving the results.[13]

The size and significance of the estimated coefficient on father's rank does not vary substantially when progressively adding fixed effects and individual level controls in columns 4 to 6. Column 4 includes federal state fixed effects. Column 5 adds a set of parental characteristics, namely educational level, age, and a dummy for being employed when their child was aged 15, for mothers and fathers, respectively. Column 6 additionally controls for the natural logarithm of the median income in mothers' and fathers' occupation. Column 6 also adds the following individual characteristics: categorical variables for age, birth order, family structure when growing up, and whether the individual has an immigrant background. The full set of coefficients are presented in Appendix 2.A in Table 2.A.3.

The coefficient on fathers' rank decreases slightly (from 0.123 to 0.113), but remains statistically significant at the 1 percent level. In the most restrictive specification in column 6, a 24 percentile increase in fathers' rank (corresponding to one standard deviation, see Table 2.2) is associated with a 2.7 percentile increase in sons' rank, which corresponds to a 5 percent increase compared to the mean of sons' rank in the sample. The positive same-sex relationship between fathers and sons is compatible with both a direct transfer of resources as well as with a transmission of gender roles. The coefficient on mothers' rank becomes smaller and then turns

[13]Results from robustness checks in which interaction effects between rank in mothers' occupation and rank in fathers' occupation are included confirm that there are no interactive effects between mothers' and fathers' rank. Instead, they appear to operate independently from each other. These results are shown in Table 2.A.5.

negative as fixed effects and control variables are added (from 0.019 to -0.013) and is never statistically significant. The level of education of mothers and fathers is not associated with the masculinity rank in sons' major, as shown in columns 5 and 6.

Panel B of Table 2.3 presents the estimates for the sample of daughters. Section 2.2 mentioned that the transmission of gender roles happens primarily via the same-sex parent. If a transmission of gender roles occurs, we would expect a positive same-sex relationship between rank in mothers' occupation and daughters' major. However, column 1 shows that the coefficient on mothers' rank is positive but small and not statistically significant. In contrast, column 2 indicates that fathers in more typically masculine occupations have daughters in less typically feminine, that is, more typically masculine majors. These findings stay very similar when mothers' and fathers' rank are jointly included (column 3) and when state fixed effects and individual level controls are successively introduced (columns 4 to 6).

In the most restrictive specification in column 6, a one percentile increase in fathers' masculinity rank is associated with a decrease in daughters' femininity rank by 0.05 percentiles. An increase of one standard deviation in fathers' rank (29 percentiles) is associated with a decrease in daughters' rank by 1.6 percentiles, corresponding to a 3 percent fall compared to the mean femininity rank of daughters' major in the sample. This coefficient is roughly half the size in absolute terms compared to fathers' rank in the specification for sons presented in column 6 of Panel A. This negative opposite-sex relationship between fathers' and daughters' rank is compatible with a direct transfer of resources between fathers and daughters. The result that fathers' - but not mothers' - rank is associated with the degree to which young women's major choices are typically female may be related to the fact that German families of the parental generation (typically 1950s/1960s birth cohorts) often follow a traditional division of work in which the father is the main breadwinner. Therefore, fathers may be more likely to transmit occupation-specific resources to their daughters and/or act as a role model compared to mothers. In line with this, the theory of direct transfer predicts that a child is more likely to draw upon the resources of the higher-status parent (Vleuten et al. 2018). This will be further

investigated in section 2.5.

Columns 5 and 6 of Panel B show that while fathers' educational level is not associated with the femininity rank in daughters' major, mothers' education is. Having a mother with a high school degree and having a mother with tertiary education is associated with an increase in daughters' rank in major by roughly 3.1 percentiles and 3.4 percentiles respectively, compared to having a mother with only basic schooling or less. The association between mothers and their daughters' major choices appears to operate not through mothers' occupation but through their educational level. Those mothers who have a high level of education are more likely to have a successful career or high-status occupation, which may explain why the mother effect operates through educational level in the context of a parental generation that often follows a traditional male breadwinner model. This interpretation, highlighting the importance of 'parental status', is supported by results from a heterogeneity analysis in which mothers' rank is interacted with a variable indicating that the mother has tertiary education (see Table 2.7).[14]

2.4.2 Robustness checks

As mentioned in section 2.3, 17.6 percent of mothers were not in employment between their child's birth and age of 15, and do not have an occupation recorded. A traditional division of work in which the father works and the mother is not in employment, also known as 'traditional male breadwinner' model is common among the parental generation, especially in West Germany (Bauernschuster & Rainer 2012). Excluding these mothers would lead to a highly biased sample in which less traditional families are overrepresented. Therefore, these mothers for who information on occupation is not recorded are assigned a femininity rank of 82, based on the fictitious occupation of 'being inactive'. Correspondingly, inactive fathers are assigned a masculinity rank of 2.

[14]In the remainder of the paper, I will present results using the specification with full set of fixed effects and control variables. Where space permits, I will also include results without any control variables.

To analyse whether this decision affects results, a robustness check in which these mothers and fathers without recorded occupation are excluded from the analysis is conducted, and the results are presented in Table 2.4. Columns 1 and 2 show results for sons and columns 3 and 4 those for daughters. While columns 1 and 3 present results without any controls, columns 2 and 4 include the full set of controls and fixed effects. The positive association between fathers' rank and sons' rank (columns 1 and 2) and the negative association between fathers' rank and daughters' rank (columns 3 and 4) both remain, and the size of coefficients is similar to those from the full sample (see Table 2.3). The coefficient on mothers' rank in the specification for sons (columns 1 and 2) remains small and not statistically significant. Interestingly, the positive coefficients on mothers' rank in the sample of daughters (columns 3 and 4) are slightly larger compared to those of the full sample, and the coefficient becomes marginally significant at the 10 percent level in column 4.

Table 2.4: Robustness check: excluding mothers and fathers without recorded occupation

Dependent variable	Sons: Masculinity rank major		Daughters: Femininity rank major	
	(1)	(2)	(3)	(4)
Rank mother's occupation	0.0010	-0.0209	0.0267	0.0329*
	(0.0157)	(0.0181)	(0.0163)	(0.0185)
Rank father's occupation	0.1154***	0.1057***	-0.0459**	-0.0452**
	(0.0230)	(0.0216)	(0.0205)	(0.0198)
Observations	2,866	2,866	5,027	5,027
R-squared	0.0125	0.0573	0.0025	0.0365
State FE	no	yes	no	yes
Parental characteristics	no	yes	no	yes
Individual characteristics	no	yes	no	yes
Parental income	no	yes	no	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

The full specification for daughters in column 4 suggests that women choose more typically female university majors if their mothers worked in more typically

female occupations and if their fathers worked in less typically male occupations, and the effect of fathers is slightly larger compared to that of mothers. Therefore, the decision to include mothers without occupation in the main set of results masks the positive effect of those mothers who have been in employment on their daughters' major choices. This finding may again be related to the fact that parents often follow a traditional division of work in which the father is the main breadwinner. Families in which the mother has been employed are less likely to follow a male breadwinner model; mothers are more likely to have a higher status, and are more likely to transmit occupation-specific resources to their daughters and act as role models. Nevertheless, the effect of fathers on daughters' rank in major is still stronger than the one of mothers. To further explore in how far the relevance of rank in mothers' occupation depends upon their status, as suggested by the direct transfer theory, additional analyses are presented in Section 2.5.

In Section 2.2 I discussed the concern that students' major choices may not accurately reflect their preferences. Specifically, students may not be able to study their desired major due to admission criteria. The main admission criterion of majors for which demand exceeds supply is high school GPA (Abiturnote). Therefore, Table 2.5 presents results from a robustness check in which the sample is restricted in one of two ways. First, a sample in which only students with a high school GPA at least as good as the median GPA of 2.2 are included (column 1 for sons and 3 for daughters); and second, a sample in which only students who indicate they were able to realise their desired major are included (column 2 for sons and 4 for daughters). The rationale is that students in these restricted samples are more likely to have entered a major that represents their actual preferences. Results do not change substantially compared to those considering the full sample of students. Column 4 reveals that for the subsample of daughters who state that they were able to realise their desired major, the positive coefficient on mothers' rank becomes weakly significant. Without further analysis, it is difficult to know why this weak link appears but it is possible that daughters do draw on the occupation-specific resources of their mothers if they are given the chance or alternatively, that the

characteristics of mothers in this subsample of daughters differ from those in the main sample.

Table 2.5: Robustness check: testing free choice

Sample	GPA 2.2 or better	Desired major realised	GPA 2.2 or better	Desired major realised
Dependent variable	Sons: Masculinity rank major		Daughters: Femininity rank major	
	(1)	(2)	(3)	(4)
Rank mother's occupation	-0.0003	0.0031	0.0182	0.0394*
	(0.0285)	(0.0211)	(0.0222)	(0.0201)
Rank father's occupation	0.1263***	0.0993***	-0.0700***	-0.0820***
	(0.0317)	(0.0245)	(0.0252)	(0.0224)
Observations	1,591	2,316	3,053	4,033
R-squared	0.0817	0.0657	0.0504	0.0451
State FE	yes	yes	yes	yes
Parental characteristics	yes	yes	yes	yes
Individual characteristics	yes	yes	yes	yes
Parental income	yes	yes	yes	yes

Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

A number of additional robustness checks are performed and their results are reported in Tables 2.A.6 and 2.A.7 of Appendix 2.A. Results from Table 2.A.6 show that the main results are robust to various variations on the analysis sample, namely including students with subject-specific school-leaving certificates (fachgebundene Hochschulreife/Fachhochschulreife, columns 1 and 2), excluding students who study towards a teaching degree (columns 3 and 4), including only those who grew up living with both biological parents (columns 5 and 6), and excluding those who are first or second generation immigrants (columns 7 and 8)[15] . The robustness of results to the inclusion of additional controls, some of which are potentially endogenous, is studied in Table 2.A.7. Results do not change substantially when including fixed effects at the level of administrative district (401 Landkreise, columns 1 and 2), or controlling

[15]The sex composition of parental occupations will vary by country and therefore I exclude those who are foreign-born or have a foreign-born parent in this robustness check.

for students' high school GPA (columns 3 and 4), high school maths grade relative to German grade (columns 5 and 6), average financial returns by major (columns 7 and 8)[16], or a dummy indicating that the mother is inactive (columns 9 and 10). Moreover, the coefficients on the dummy indicating that the mother is inactive are not statistically significant, suggesting that this variable is not independently associated with rank in sons' or daughters' major.

Finally, to check how the selectivity of the sample of highly educated students affects results, I use NEPS data of a sample of grade 9 school students (NEPS-SC4). NEPS Starting Cohort 4 is a sample of a nationally representative cohort of students in compulsory schooling. I estimate regressions of the probability to enter university on fathers' masculinity rank and mothers' femininity rank in occupation. The results are reported in Appendix 2.A in Table 2.A.8. Overall, results indicate that the rank in parental occupation has no effect on sons' and very small effects on daughters' likelihood to enter university. On the other hand and in line with prior research documenting low intergenerational educational mobility (Heineck & Riphahn 2009), there are large effects of parental level of education on sons' and daughters' probability of starting a university degree and they are mainly same-sex intergenerational correlations. Taken together, this subsection showed that the paper's main findings are robust to a number of robustness checks, including different subsamples and additional control variables.

To sum up, results suggest that daughters choose more typically female university majors if their fathers worked in less typically male occupations and if their mothers worked in more typically female occupations. The positive same-sex correlation between mothers and daughters is significant only when excluding mothers who have not been employed since their child was born. Sons select more typically male university majors if their fathers worked in more typically male majors, and this

[16] Average financial returns by major are obtained from regressions of the average salary paid in the first job after graduation on group of university major, controlling for age and square of age at graduation, federal state of the job, female dummy, dummy for having studied at FH (university of applied sciences), and year of graduation. The underlying data are the 2005 and 2009 DZHW Graduate Panel Survey.

effect is roughly twice the size in absolute terms compared to the father-daughter correlations. The association between mothers' and sons' ranks is close to zero and never statistically significant.

The positive same-sex correlations are compatible with both a direct channel of resource transfer and an indirect channel of the transmission of gender roles. In contrast, the negative opposite-sex correlations between fathers and daughters are only compatible with a direct transfer of resources. These potential channels will be explored in more detail in section 2.5.

2.4.3 Non-linearity of intergenerational transmission

I next investigate how these findings vary across the distribution in the gender-typicality rank of university major. Figure 2.2 presents the coefficients and 95 percent confidence intervals on rank in mother's occupation (top panel) and father's occupation (bottom panel) from quantile regressions at the 10th to the 90th percentile of the distribution in major rank, for daughters (left-hand side) and sons (right-hand side). All specifications include the full set of control variables. Overall, the statistically significant positive father-son and negative father-daughter correlations and the finding that mothers' rank is not related to sons' nor daughters' major choices holds across the majority of points in the distribution of rank in students' major.

Moreover, the coefficient on mothers' rank is quite stable across the different quantiles in the distribution of daughters' and sons' rank in major. The size of the father effect, on the other hand, varies across the distribution of rank in major. It takes an approximate (albeit skewed) U-shape for the sample of daughters and a (skewed) inverse U-shape for the sample of sons. For both the sample of daughters and the sample of sons, the coefficient on fathers' rank is largest in terms of absolute size between the 20th and the 50th percentile of the dependent variables. This suggests that the effect of fathers' rank is driven by daughters who choose less typically feminine (gender-atypical) and by sons who choose less typically male

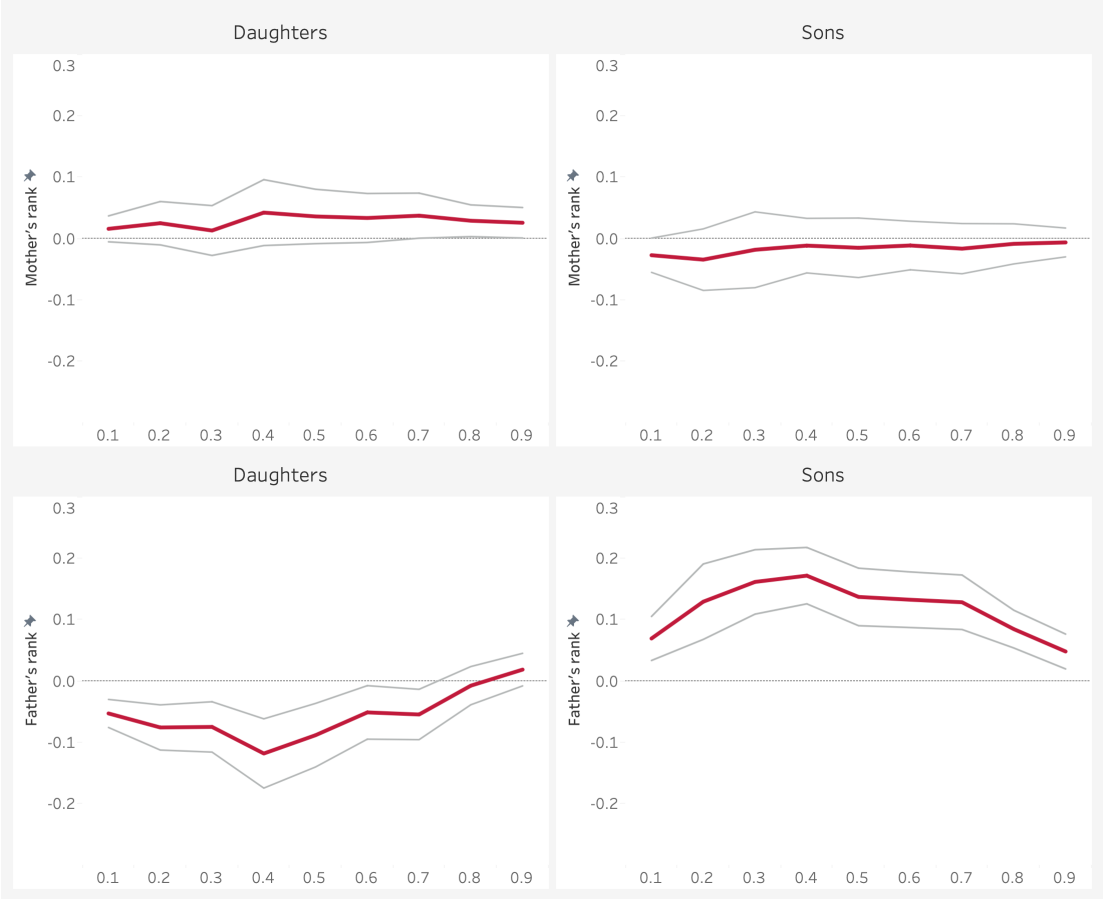

Figure 2.2: Quantile regressions

Notes: Figures show coefficients and 95 percent confidence intervals from quantile regressions at different quantiles of the dependent variable. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. The full set of control variables is included: age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively), two dummies for birth order, three dummies for family structure when growing up, a binary variable indicating (1st or 2nd generation) immigrant background, and natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

(gender-atypical) university majors. In particular, there appear to be stronger associations up until roughly the median of the distributions in sons' and daughters' rank. This suggests that the main results are driven by sons and daughters who defy gender-stereotypical major choices.

Next, I explore whether the strength of these intergenerational associations not

only varies across the distribution of the dependent variable, but also across the distribution of the key regressors. To this end, I perform regressions in which I interact the rank in mothers' occupation with a binary variable taking a value of one if the rank in mothers' occupation is at least 50 (and zero otherwise), and interact the rank in fathers' occupation with a binary variable taking a value of one if the rank in fathers' occupation is at least 50 (and zero otherwise). I choose rank 50 as a cutoff to indicate a 'gender-typical' occupation as this roughly appears to be the turning point for the dependent variables, as shown in Figure 2.2. The results are presented in Table 2.6. In line with previous results, the coefficients on mothers' rank do not appear statistically significant (neither for sons nor for daughters) and this holds true for both the lower half as well as the upper half of the distribution in mother's rank. The coefficients on the interaction effect between mothers' rank and a dummy indicating rank is larger than 50 are not statistically significant either.

For fathers, on the other hand, there is again evidence for a non-linear effect in intergenerational transmission. Results for the sample of sons (columns 1 and 2) show that the positive association between father's rank and sons' rank is statistically significant only for fathers with a rank below 50. For fathers with a rank of 50 or above, the coefficient on fathers' rank is close to zero and not statistically significant (as indicated by the linear combination of estimates) and this difference compared to fathers with a rank of at least 50 is statistically significant, as indicated by the interaction effect. The results for the sample of daughters (columns 3 and 4) paint a similar picture. The negative association between masculinity rank in fathers' occupation and femininity rank in daughters' major is statistically significant only for fathers' ranks up to 50. For ranks of 50 and higher, the coefficient is close to zero and not statistically significant (linear combination of estimates) and this difference is statistically significant, as indicated by the interaction effect.

Taken together, results from Figure 2.2 and Table 2.6 support the main takeaways in terms of statistical significance and signs of key regressors from the linear regression results presented in Table 2.3. Moreover, they reveal important non-linear effects in intergenerational transmission. They show that the positive father-son

correlations and the negative father-daughter correlations are driven by those in gender-*atypical* occupations and university majors. Sons with fathers in gender-atypical occupations choose less typically male university majors, thus breaking gender stereotypes. Daughters with fathers in gender-atypical occupations choose more typically female majors, though this effect seems to disappear for daughters choosing majors with a very high femininity rank. These non-linearities are important to bear in mind when interpreting the results and considering resulting policy implications.

Table 2.6: Interaction effects to test linearity of intergenerational transmission

Dependent variable	Sons: Masculinity rank major		Daughters: Femininity rank major	
	(1)	(2)	(3)	(4)
Rank mother's occup.	0.0773	0.0309	-0.0178	-0.0176
	(0.0557)	(0.0563)	(0.0520)	(0.0514)
Dummy rank mother ≥ 50	-5.8181*	-2.7167	3.6310	2.3164
	(3.3341)	(3.5664)	(2.9201)	(2.9015)
Rank mother's occup. x rank ≥ 50	0.0237	0.0011	-0.0154	0.0040
	(0.0670)	(0.0687)	(0.0634)	(0.0622)
Rank father's occup	0.1551***	0.1867***	-0.1398***	-0.1480***
	(0.0428)	(0.0415)	(0.0364)	(0.0374)
Dummy rank father ≥ 50	8.7344**	9.0137**	-8.4503*	-7.1802*
	(4.2616)	(4.5767)	(4.4005)	(4.0591)
Rank father's occup. x rank ≥ 50	-0.1362*	-0.1731**	0.1813***	0.1654***
	(0.0698)	(0.0731)	(0.0657)	(0.0617)
Linear combination of estimates				
Lincom mother	0.101**	0.0320	-0.0332	-0.0136
	(0.0422)	(0.0476)	(0.0353)	(0.0364)
Lincom father	0.0189	0.0136	0.0414	0.0174
	(0.0570)	(0.0596)	(0.0585)	(0.0533)
Observations	3,540	3,540	6,100	6,100
R-squared	0.0174	0.0596	0.0048	0.0364
State FE	no	yes	no	yes
Parental characteristics	no	yes	no	yes
Individual characteristics	no	yes	no	yes
Parental income	no	yes	no	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

In Section 2.3, I mentioned that categorial regressors have several disadvantages:

they impose arbitrary cutoffs on what constitutes a gender-typical occupation, the categorisation implies a significant loss in relevant information, and the interpretation of results is dependent on the choice of an arbitrary baseline category. Nevertheless, as a robustness check, in Table 2.A.9 in Appendix 2.A, I present results for categorical regressors. Results from these tables provide further support for the interpretation that the father-son and father-daughter correlations are primarily driven by fathers in less typically masculine occupations.[17]

2.5 Direct versus indirect channel of intergenerational transmission

Section 2.2 described direct resource transfers and transmission of gender roles as two potential channels that can account for the results presented in section 2.4. In this section, I study the presence of these two channels through a number of different heterogeneity analyses.

2.5.1 Direct transfer of resources

Results presented in the previous section showed that fathers' - but generally not mothers' - rank is significantly correlated with the degree to which young women's and men's major choices are typically female and male, respectively. Results also revealed that mothers in more typically female occupations have daughters in more typically female majors, if these mothers were employed at some stage while raising

[17]Specifically, I present results for categorical regressors, in which gender-typicality in parental occupation can take one of three categories: Occupations with rank 30 or below are considered as gender-atypical, those with rank 31 to 69 are considered as gender-neutral (omitted category in regressions), and those with rank 70 or above are considered as gender-typical. The coefficient on gender-atypical occupation of fathers is statistically significant but the coefficient on gender-typical occupation is not. Specifically, daughters with a father in a gender-atypical occupation choose a major with a 3.9 higher rank compared to those with fathers in a gender-neutral occupation (column 6). Sons with a father in a gender-atypical occupation (compared to those with fathers in a gender-neutral occupation) choose a major with a 6.6 lower gender-typicality rank (column 3). Moreover, mother's occupation is generally not related to students' rank although the coefficient on mothers in a gender-atypical occupation for the sample of daughters is negative and marginally significant (column 4), in line with previous results.

children. Taken together, these findings suggest that the more important role of fathers in the study sample may be related to the fact that German families of the parental generation often follow a traditional division of work in which the father is the main breadwinner. That is, the father typically works full-time and the mother does not work or works part-time (Holst & Wieber 2014). Indeed, according to the theory of direct transfer ('direct channel'), young adults are more likely to identify with and use the resources of the higher-status parent (Vleuten et al. 2018).

To test the plausibility of a direct transfer of resources, I analyse whether results vary across parental status. To do so, I perform three different heterogeneity analyses, presented in Table 2.7.[18] In the first, I interact mothers' and fathers' rank with a dummy indicating whether they have tertiary education. The rationale is that tertiary education is an indicator of social status and results from Table 2.3 showed that mothers' educational level is associated with daughters' femininity rank in major. In the second heterogeneity analysis, I interact the parental rank variables with a dummy for whether the individual went to school in East Germany when aged 15. The rationale behind this variable is that couples in East Germany on average have a more equal division of work, which is a result of the differences in family policy between East and West Germany during the divided years (Bauernschuster & Rainer 2012, Holst & Wieber 2014). Specifically, while West German policy encouraged a traditional male breadwinner model in which fathers worked and mothers stayed at home, East German policy encouraged a reconciliation of motherhood and work (Bauernschuster & Rainer 2012). Finally, I interact the parental rank variables with a dummy for whether the individual grew up living with the mother only. While this is a measure of intensity of parental contact, mothers in the sample who raise children living without a partner are also more likely to have higher status. Specifically, they are more likely to possess a tertiary degree and be employed at the time their daughter or son was 15.

[18]Ideally, heterogeneity analyses would study how results vary across different family working time arrangements and relative parental income. Unfortunately, there is no information available on whether a parent worked part-time or full-time or on parental income, so this is not possible. I therefore conduct alternative heterogeneity analyses to proxy relative parental status.

Table 2.7: Channel: direct transfer of resources

Dependent variable	Sons: Masculinity rank major			Daughters: Femininity rank major		
	(1)	(2)	(3)	(4)	(5)	(6)
Rank mother's occup.	-0.0081	-0.0012	-0.0019	0.0133	0.0155	0.0251
	(0.0194)	(0.0185)	(0.0164)	(0.0187)	(0.0189)	(0.0170)
Mother tertiary degree	-1.5331			1.3336		
	(2.6666)			(2.1872)		
Mother: tertiary x rank	-0.0051			0.0383		
	(0.0407)			(0.0311)		
Rank father's occup.	0.0759***	0.1092***	0.1111***	-0.0263	-0.0437**	-0.0589***
	(0.0230)	(0.0202)	(0.0196)	(0.0196)	(0.0200)	(0.0194)
Father tertiary degree	-6.6496***			2.9826		
	(2.5014)			(2.0209)		
Father: tertiary x rank	0.1387***			-0.1159***		
	(0.0406)			(0.0373)		
Dummy East Germany		-8.1227			17.4141***	
		(5.7517)			(5.3234)	
East x mother's rank		-0.0472			0.0462	
		(0.0326)			(0.0373)	
East x father's rank		0.0151			-0.0475	
		(0.0418)			(0.0399)	
Mother only			5.5460			-1.4653
			(4.3333)			(4.0261)
M. only x mother's rank			-0.1668***			0.0196
			(0.0590)			(0.0562)
M. only x father's rank			0.0293			0.0627
			(0.0651)			(0.0575)
Linear combination of estimates						
Lincom mother	-0.0132	-0.0485*	-0.169***	0.0516*	0.0617*	0.0446
	(0.0333)	(0.0281)	(0.0574)	(0.0278)	(0.0326)	(0.0550)
Lincom father	0.215***	0.124***	0.140**	-0.142***	-0.0912**	0.0038
	(0.0344)	(0.0404)	(0.0647)	(0.0350)	(0.0366)	(0.0538)
Observations	3,540	3,540	3,513	6,100	6,100	6,058
R-squared	0.0603	0.0577	0.0595	0.0366	0.0351	0.0344
State FE	yes	yes	yes	yes	yes	yes
Parental characteristics	yes	yes	yes	yes	yes	yes
Individual characteristics	yes	yes	yes	yes	yes	yes
Parental income	yes	yes	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Columns 1 to 3 of Table 2.7 present results for the sample of sons and columns 4 to 6 for daughters. Column 1 shows that mothers' rank is not significantly associated with sons' major, independently of her educational level. The positive effect of fathers' masculinity rank on sons' masculinity rank holds independently of fathers' education, but it is significantly stronger if fathers have tertiary education. Column 2 shows that the effect of parental rank does not depend on whether the son grew up living in East Germany. Finally, column 3 indicates that there is a positive father-son correlation in masculinity rank, independently of whether the son grew up living with both parents. However, the coefficient on the interaction between mothers' rank and the dummy variable of living with the mother only is negative and statistically significant. Mothers in a more typically female occupation have sons in less typically male majors, for those who grew up living with the mother only.

Moving on to daughters, column 4 shows that the coefficients on mothers' rank and fathers' rank, which show the effect for those mothers and fathers without a tertiary degree, are not statistically significant. Fathers in more typically male occupations who have tertiary education, however, have daughters in less typically female majors, and the interaction term is statistically significant. Moreover, mothers in more typically female occupations who are tertiary-educated have daughters in more typically female majors (the coefficient is statistically significant at the 10 percent level). However, the interaction term is not statistically significant. Column 5 presents the results distinguishing between East and West Germany. For the sample of daughters going to school in West Germany, only the father-daughter correlation is statistically significant. On the other hand, for those growing up in East Germany the coefficient on mothers' rank increases to 0.062 and becomes significant at the 10 percent level (though the coefficient on the interaction term is not statistically significant). Finally, column 6 shows that the negative father-daughter correlation is only statistically significant for daughters who grew up living with both parents. On the other hand, the coefficient on mothers' rank is larger (but imprecisely estimated) for daughters who grew up living with mothers only, even

though the interaction term is not statistically significant.

In sum, the coefficient on fathers' rank in the sample of sons is positive and statistically significant independently of fathers' status, but the effect size is significantly larger when fathers have tertiary education. Sons' choice is significantly associated with mothers' rank only if they grew up living with the mother only. This could be explained by the higher intensity of contact with the mother, or by the fact that single mothers on average have higher status. For daughters, the coefficient on mothers' rank is larger if the latter possess a tertiary degree, and if daughters grew up living in the East or grew up living with the mother only, but the interaction terms are not statistically significant. In contrast, the significant effect of fathers on daughters disappears for fathers without tertiary education and for daughters who grew up living with a mother only. Taken together, these results indicate that parental status does indeed matter for the correlation between rank in parental occupation and offspring's major choice. This suggests that the direct transfer of resources from parents to their children constitutes a relevant channel for the correlation between gender-typicality rank in parental occupation and gender-typicality rank in offsprings' major.

2.5.2 Transmission of gender roles

Section 2.2 stated that, in addition to a direct resource transfer, a second 'indirect channel' is likely present if children choose majors that are unrelated to their parents' occupations and we still observe a significant association between gender-typicality in parental occupation and gender-typicality in children's majors. In such a case, the possibility of direct resource transfers is much more limited, and therefore a significant association can be interpreted as strong evidence for the transmission of gender roles. Empirically, this can be tested by studying heterogeneous effects across those children who choose majors that are related to the same field as their parents' occupations and those whose majors are unrelated to parents' occupations.

To do so, it is necessary to map each major with an occupational field. The

appropriate mapping of parental occupational fields to groups of majors is in many cases not obvious. Therefore, I use a classification developed for the German Student Survey, which maps university majors to occupational fields (see Georg & Bargel 2017).[19] The mapping is shown in Table 2.8. The table shows that each of nine broad groups of university majors are mapped to one of nine broad fields of occupations. The broader the groups, the more likely it is that fields are sufficiently distinct from each other so that the direct transfer of resources is indeed blocked as a channel as good as possible. For example, all university majors within natural sciences, mathematics, and computer science constitute one group and are mapped to all occupations within the natural sciences sector, such as laboratory assistants.

Table 2.8: Mapping of occupations to university majors

University majors	Occupations
Humanities, social sciences, theology, languages	Print media, electronic media, librarianship, foreign languages (e.g.journalism, publishing, librarianship)
Social sciences, education, pedagogy, psychology	Education and social services (e.g. nursery school teacher, social service provider, youth services)
Legal studies	Administrative, legal, security (e.g. paralegal, police, air traffic controller)
Economics and industrial engineering	Commercial sector/trade/banking (e.g. administrative assistant, actuary, trade association)
Medicine, dentistry, veterinary medicine, pharmacy	Health care, nursing, optometry, pharmacy (e.g. medical assistant, medical technicians, opticians, dental technician)
Natural sciences, mathematics, computer science	Natural science sector (e.g. chemical laboratory assistant, laboratory assistant)
Engineering and architecture	Technology, metallurgy, electronics, building, timber/ lumber industry, IT (e.g. locksmith, mechanic, electrician)
Agronomy, forestry, and nutritional science	Nutrition, gastronomy/hotel, catering (e.g. baker, cook, waiter); agriculture and home economics, horticulture (e.g. gardener, florist, agricultural manager)
Fine arts, music, theatre, film school	Fine art, design, music sector (e.g. photographer, interior decorator, coutourier)
Other disciplines	Other occupations

Source: Georg and Bargel (2017).

In addition to similarity of field, as demonstrated, direct resource transfer is more likely if parents have a higher status. Therefore, I define a dummy variable called 'direct transfer mother' which takes a value of one if the following two conditions are met: the mother has tertiary education and the student chooses a major that is in the same broad field as mother's occupation, according to Table 2.8. The variable

[19]The German Student Survey (Studierendensurvey) is a survey of students at German universities conducted by the research group on higher education at the University of Konstanz. It aims to provide information on student orientations and the study situation, and has been conducted regularly since the 1980s.

takes a value of zero otherwise. I define a dummy variable called 'direct transfer father' in the same way.

Table 2.9: Channel: transmission of gender roles

Dependent variable	Sons: Masculinity rank major		Daughters: Femininity rank major	
	(1)	(2)	(3)	(4)
Rank mother's occupation	0.0127	-0.0068	0.0100	0.0063
	(0.0162)	(0.0157)	(0.0148)	(0.0165)
Direct transfer mother	-2.2087	-1.7456	-3.4149	-3.3175
	(4.0679)	(4.2721)	(2.7905)	(2.8414)
Direct transfer mother x mother's rank	-0.3789***	-0.3356***	0.2678***	0.2625***
	(0.0919)	(0.0960)	(0.0625)	(0.0598)
Rank father's occupation	0.0784***	0.0591***	-0.0187	-0.0219
	(0.0218)	(0.0204)	(0.0184)	(0.0177)
Direct transfer father	-31.2764***	-29.7093***	19.8305***	18.5075***
	(3.9216)	(3.6297)	(2.9039)	(2.7351)
Direct transfer father x father's rank	0.8146***	0.8139***	-0.8228***	-0.8088***
	(0.0748)	(0.0731)	(0.0750)	(0.0708)
Linear combination of estimates				
Lincom mother	-0.366***	-0.342***	0.278***	0.269***
	(0.0893)	(0.0952)	(0.0637)	(0.0605)
Lincom father	0.893***	0.873***	-0.842***	-0.831***
	(0.0721)	(0.0710)	(0.0743)	(0.0711)
Observations	3,540	3,540	6,100	6,100
R-squared	0.0599	0.0982	0.0326	0.0631
State FE	no	yes	no	yes
Parental characteristics	no	yes	no	yes
Individual characteristics	no	yes	no	yes
Parental income	no	yes	no	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Direct transfer indicates that major matches parents' occupational group according to Table 2.8 and parent has tertiary education. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Table 2.9 presents the results in which I interact mothers' and fathers' rank with the 'direct transfer' variables. The table reports results for sons without any controls (column 1) and with federal state fixed effects and individual level controls (column 2), and for daughters without and with controls (columns 3 and 4, respectively). The coefficients on the interaction effects between parental rank and the 'direct transfer'

indicators are statistically significant and large in absolute terms in all cases. The linear combination of estimates shown at the bottom of the table indicates that in the cases in which 'direct transfer' occurs, there is a positive and statistically significant same-sex association between rank of fathers and sons, as well as between mothers and daughters. Moreover, there is a negative and significant opposite-sex association between mothers and sons, as well as between fathers and daughters. The effects are quite large compared to the main results reported in section 2.4. For example, for daughters who choose a major in which direct transfer from the father occurs, a one percentile increase in fathers' masculinity rank is associated with a 0.83 decrease in daughters' femininity rank in major.

In contrast, the coefficients on mothers' rank and fathers' rank are not statistically significant in most cases. This means that in those cases where the 'direct transfer' is blocked, mothers' and fathers' rank are not significantly associated with offsprings' choices. The only exception is the coefficient on fathers' rank in the sample of sons. In the full specification in column 2 it takes a value of approximately 0.06, suggesting that in those cases where sons choose a major where the direct transfer of resources is unlikely to occur, a one percentile increase in fathers' masculinity rank is associated with a 0.06 increase in masculinity rank in sons' major.

Overall, the 'direct transfer of resources' channel seems to account for a large part of the results. There is no direct evidence for the existence of an 'indirect channel' for the associations between fathers and daughters, mothers and daughters, as well as mothers and sons. However, a transmission of gender roles may still occur *within* the group of students who choose a major closely related to parental occupation. Given the broad categories of the mapping of majors to occupations, the potential importance of this possibility should not be discarded. Moreover, there is strong evidence of the transmission of gender roles as a relevant channel for the associations in masculinity rank between fathers' occupations and sons' majors.

2.6 Discussion and conclusion

Using data of a nationally representative cohort of first-year undergraduate students in Germany, I have focused on the role of parental socialisation during adolescence for gendered university major choices in early adulthood. I examined whether femininity of mothers' occupation and masculinity of fathers' occupation are related to whether their adult children choose typically male or female majors at university, and if so, why. To operationalise femininity and masculinity in occupations and majors, I construct novel percentile rank measures. These define the degree of masculinity or femininity in majors and occupations relative to others of the same cohort and sex.

The findings indicate that the gender-typicality rank in parental occupation matters for students' gendered university major choices. I find that daughters choose more typically female university majors if their fathers worked in less typically male occupations when the daughters were teenagers. An increase of one standard deviation in fathers' masculinity rank (29 percentiles) decreases daughters' rank by 3 percent (1.6 percentiles). I also find that daughters choose more typically female majors if their mothers worked in more typically female occupations, given certain conditions: if those mothers were in employment after the birth of their daughter, if mothers possess tertiary education, if daughters grew up living in East Germany, or in cases where a 'direct transfer of resources' is possible.

Sons select less typically male university majors if their fathers worked in less typically male occupations but they are not influenced by their mothers' occupation. A one standard deviation increase in fathers' masculinity rank (24 percentiles) is associated with a 5 percent increase in masculinity rank of sons' major (2.7 percentiles). As one would expect, the size of coefficients is considerably smaller compared to those of intergenerational income rank correlations found in the literature (e.g. Chetty et al. 2014). While the effect sizes are modest, I identified a consistent and robust association despite only considering one specific aspect of parental behaviour.

Results from quantile regressions and heterogeneity analyses show that the posi-

tive father-son correlations and the negative father-daughter correlations are driven by those in gender-*atypical* occupations and university majors. These results suggest that fathers in gender-atypical occupations can help break gender stereotypes and that the findings of the paper are at least partially driven by sons and daughters who defy gender-stereotypical major choices.

It is important to note that intergenerational transmission is not the same for mothers and fathers: heterogeneity analyses by parental education showed that fathers' rank is significantly associated with sons' rank independently of their status but with daughters' rank only if they have a tertiary degree. Mothers often have less successful careers than fathers and lower levels of education; their rank in occupation is only significantly associated with daughters' rank under certain conditions, and is not correlated with sons' rank. These asymmetries highlight the need to study both same-sex and opposite-sex intergenerational correlations between mothers and fathers on the one hand, and daughters and sons on the other hand. Much of previous research on intergenerational transmission of income and education has focused solely on fathers (e.g. Lefgren et al. 2012).

I identified two distinct channels through which these intergenerational correlations can operate, a direct transfer of resources and a transmission of gender roles. Large intergenerational correlations for children that choose a major related to parental occupational field suggest that the direct transfer of resources plays an important role. Moreover, intergenerational correlations are stronger if parents have a higher status, measured for example by parental educational level. This provides additional support for a direct transfer of resources as children are more likely to draw upon the resources of a higher status parent (Vleuten et al. 2018). For daughters in particular, parental status mediates whether there is a significant correlation with mothers or with fathers, or both.

An analysis of intergenerational correlations for children who chose majors unrelated to the occupational group of their parents was conducted to identify the transmission of gender roles. Significant father-son correlations provided support for a transmission of gender roles. Dominant cultural gender beliefs and stereotypes

thus lead to a reproduction of sex segregation in the labour market through the "different and seemingly voluntary choices men and women make" (Correll 2001, p. 1725). On the other hand, results suggest that fathers in gender-atypical occupations can help break gender stereotypes and encourage sons to choose a more gender-atypical university major. While the paper did not identify direct evidence of the transmission of gender roles between mothers and daughters, it may still occur *within* the group of students who choose a major closely related to parental occupation.

The finding that a transmission of gender roles occurs predominantly between fathers and sons is in line with the observation that despite the increasing number of women entering male-dominated occupations, men continue to be reluctant to enter into female-dominated occupations (England 2010). Previous research also suggests that male gender norms are more restrictive (Koenig 2018). This points to a shortcoming of existing literature on intergenerational transmission of gender roles, where the predominant focus has been on women (e.g. van Putten et al. 2008, Morrill & Morrill 2013, Fernández & Fogli 2009, Olivetti et al. 2020). In light of this, the finding that the positive association between rank in father's occupation and rank in sons' major is primarily driven by fathers and sons in less typically masculine occupations/majors is therefore especially encouraging.

Germany constitutes an interesting context for examining the role of parental occupation for gendered major choices. This is because it provides a relatively traditional setting in which a high share of mothers in the parental generation did not work after having children and in which fathers are more likely to have a higher-status career and higher level of education than mothers.

This traditional gender norms setting may explain why the findings of this paper contrast those from previous research in the Nordic countries. A study in Denmark (Humlum et al. 2018) identifies positive same-sex intergenerational correlations for both sons' and daughters' sex composition in major. Previous research from the Netherlands (Vleuten et al. 2018) has found that mothers in typically female occupations affect both sons' and daughters' field of study choices in secondary school,

and that fathers' occupation matters less. The larger role played by mothers' behaviour could be due to the fact that the Nordic countries are more gender-equal. Another possibility is that especially the relevance of mothers in the Dutch context may be due to the fact that the study focuses on field of study choices in secondary school, and it is possible that mothers are more influential role models when children are at a younger age.

The results from this study have important implications. First, the relevance of parental occupation shows the importance of policies that address roots of segregation that happen early in life through socialisation. One example is to invest in educational programmes designed to encourage 'atypical' choices among teenagers and to promote new role models, as showcased by initiatives such as 'Girls' day' and 'New pathways for boys' in Germany (Bettio & Verashchagina 2009). These initiatives intend to widen the occupational aspirations of girls and boys. Results from this paper suggest that especially men in 'gender-atypical' occupations may encourage boys to aspire to less typically male occupations.

Second, the interactive effect of parental status with masculinity/femininity in parental occupation implies that high-status parents can serve as role models independent of whether they are of the same gender as their child. It also highlights the fact that successful role model identification is contingent on status and perceived desirability.

Third, while it is important to encourage women to enter highly paid STEM fields, policy should also aim at changing men's attitudes and encouraging them to enter traditionally female-dominated fields. Results from this paper suggest that one avenue could be to stimulate men's interest in typically female fields by challenging traditional stereotypes.

Finally, the findings speak to Charles and Bradley's (2009) argument that higher levels of gender equality in terms of female labour force participation and gender pay gaps does not necessarily come hand in hand with a disappearance of gendered major and occupational choices. To the contrary, the authors argue that privilege and economic development create opportunities for the expression of 'gendered selves'.

That is, as women in Germany have more equal careers compared to their male counterparts and achieve a higher status, perhaps we will see more rather than less sex segregation. The finding that higher levels of mothers' education are associated to daughters choosing more typically female majors supports this notion. Therefore, breaking gender stereotypes from early on becomes all the more important and progress should not be expected to happen automatically.

This paper has focused in detail on gender-typicality in parental occupation, a previously unexplored determinant of the persistence of gendered university major choices in Germany. Future research could extend this in various ways. Specifically, the paper has focused on choice of major when entering university. It would be interesting to study how gender-typicality of parental occupation and entry to a gender-typical major affect the probability to drop out, switch major, and successfully obtain a university degree. With regards to external validity, it is possible that results are different among individuals with lower levels of education. Therefore, future research could explore whether the intergenerational transmission and its underlying channels are different when studying for example vocational education choices. Moreover, findings from this paper suggest important non-linearities in intergenerational associations. Future research could build on the rank measure used in this paper by further modeling non-linear relationships in ways that do not impose arbitrary cutoffs in what constitutes a gender-typical occupation or university major. Finally, most papers including this one, focus on one specific determinant of major choice. Future research that considers the relative importance of different socialisation agents, including peers and teachers, would therefore be valuable.

2.A Appendix figures and tables

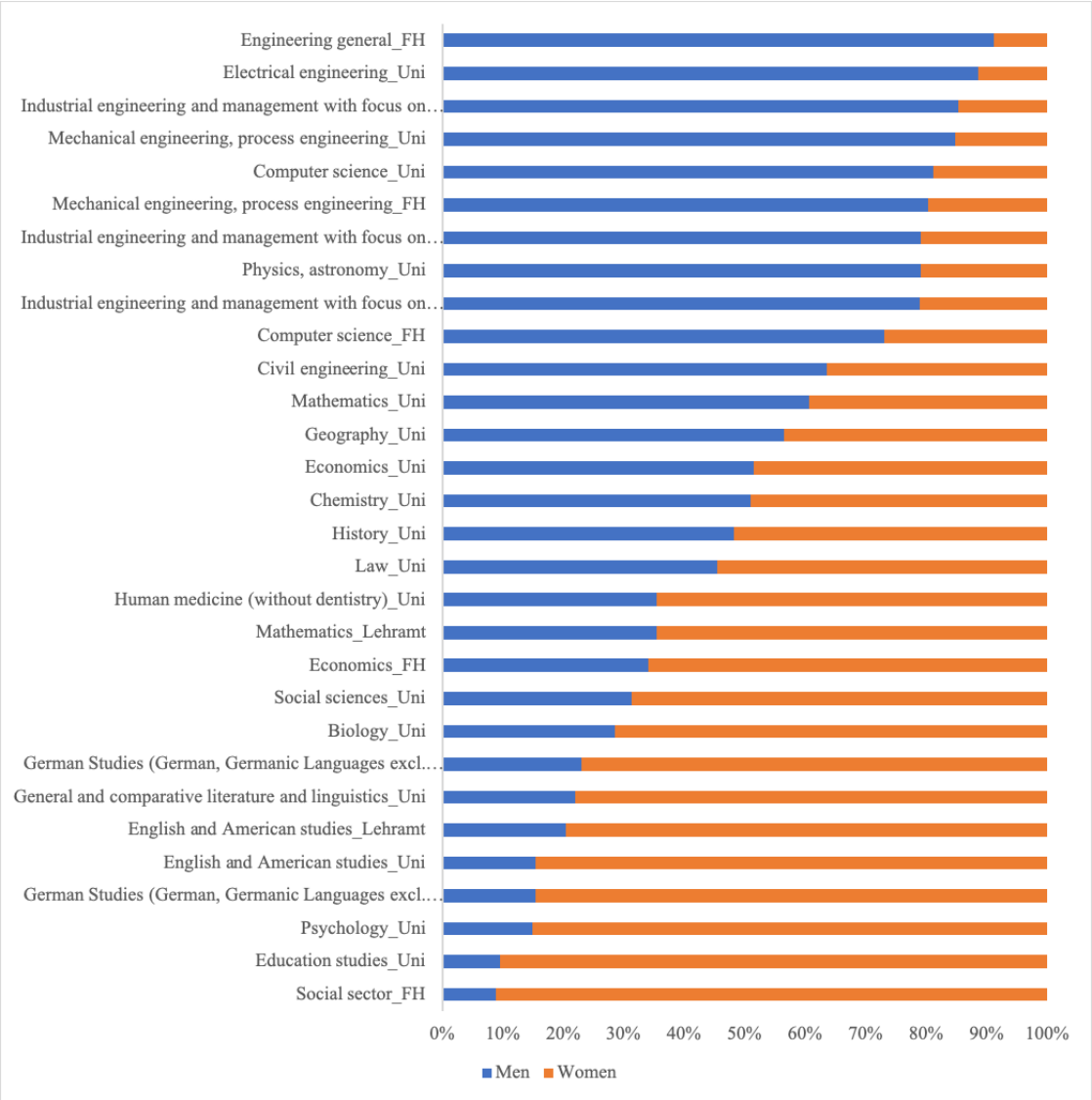

Figure 2.A.1: Sex composition of the 30 most common university majors.

Source: NEPS-SC5.

Table 2.A.1: Sample selection

	Initial full sample				Aged 18 to 25 with general school leaving certificate				Final sample: missing obs. on key covariates dropped			
	Men		Women		Men		Women		Men		Women	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mother employed	0.71		0.75		0.72		0.75		0.71		0.74	
Father employed	0.95		0.94		0.96		0.95		0.96		0.95	
Mother lower secondary or less	0.2		0.19		0.15		0.15		0.15		0.16	
Mother intermediate secondary	0.37		0.37		0.37		0.37		0.37		0.36	
Mother upper secondary	0.17		0.17		0.18		0.18		0.17		0.18	
Mother tertiary degree	0.25		0.27		0.3		0.3		0.31		0.30	
Father lower secondary or less	0.23		0.23		0.18		0.2		0.18		0.19	
Father intermediate secondary	0.26		0.26		0.26		0.25		0.26		0.25	
Father upper secondary	0.13		0.13		0.13		0.14		0.13		0.14	
Father tertiary degree	0.38		0.38		0.43		0.42		0.44		0.42	
School aged 15 in East Germany	0.2		0.22		0.21		0.21		0.20		0.20	
Gender-typicality rank major	55.3	24.7	50.8	32.1	52.5	24.4	50.3	31.3	51.6	24.4	51.2	31.3
Age	21.7	3.4	21.5	4.8	20.5	1.2	20.2	1.5	20.5	1.2	20.2	1.5
Rank mother's occupation	54.6	26	53.8	32.4	53.3	25.9	53.2	31.9	53.4	25.9	53.1	32.1
Rank father's occupation	44.4	24.1	43.8	30.1	42.9	23.7	43.1	29.4	42.8	23.6	43.2	29.3
Mother's age	50	5.5	50.1	6.9	49.2	4.5	49.2	5.4	49.3	4.4	49.2	5.4
Father's age	53	6.2	52.9	7.7	52.2	5.4	51.9	6.4	52.1	5.2	51.9	6.4
N	7,082		10,828		5,169		8,881		3,540		6,100	

Notes: Lower secondary school or less means Hauptschulabschluss or no secondary school leaving certificate. Intermediate secondary means Mittlere Reife. Upper secondary means general or subject-linked school leaving certificate (Allgemeine Hochschulreife or Fachhochschulreife). Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: NEPS-SC5.

Table 2.A.2: Summary statistics

	Men		Women		Total	
	Mean	SD	Mean	SD	Mean	SD
Gender-typicality percentile rank in major	51.6	24.4	51.2	31.3	51.4	28.2
Dummy university of applied sciences (FH)	0.277		0.209			0.240
Dummy teaching degree	0.067		0.164			0.119
Age	20.5	1.2	20.2	1.5	20.3	1.4
Femininity rank of mother's occup.	53.4	25.9	53.1	32.1	53.2	29.3
Masculinity rank of father's occup.	42.8	23.6	43.2	29.3	43	26.8
Mother's age	49.3	4.4	49.2	5.4	49.3	5
Father's age	52.1	5.2	51.9	6.4	52	5.8
Mother inactive	0.187		0.167			0.176
Father inactive	0.007		0.010			0.009
Mother employed	0.711		0.736			0.725
Father employed	0.964		0.953			0.958
Mother lower secondary or less	0.146		0.158			0.152
Mother intermediate secondary	0.371		0.364			0.367
Mother upper secondary	0.174		0.178			0.176
Mother tertiary degree	0.309		0.301			0.305
Father lower secondary or less	0.180		0.193			0.187
Father intermediate secondary	0.258		0.252			0.255
Father upper secondary	0.125		0.138			0.132
Father tertiary degree	0.437		0.417			0.426
Ln median income in mother's occup. group	6.4	2.8	6.6	3.2	6.5	3
Ln median income in father's occup. group	8	0.7	7.9	0.9	8	0.8
Birth order: first born	0.377		0.377			0.377
Birth order: second or higher born	0.480		0.489			0.485
Birth order: only child	0.143		0.134			0.138
Grew up living w. biological parents	0.906		0.896			0.901
Grew up living w. mother only	0.064		0.066			0.065
Grew up living w. mother & stepfather	0.022		0.030			0.026
Grew up living w. other	0.008		0.009			0.008
Dummy 1st or 2nd generation immigrant	0.152		0.149			0.150
Dummy school at age 15 in East Germany	0.197		0.199			0.198

Notes: Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Mother/father inactive means that they have not been employed in the period between the birth of the individual and the individual reaching age 15. Lower secondary school or less means Hauptschulabschluss or no secondary school leaving certificate. Intermediate secondary means Mittlere Reife. Upper secondary means general or subject-linked school leaving certificate (Allgemeine Hochschulreife or Fachhochschulreife). Source: NEPS-SC5.

Table 2.A.3: Full set of coefficients of baseline rank-rank regressions, sons

Dependent variable	Sons: Masculinity rank major					
	(1)	(2)	(3)	(4)	(5)	(6)
Rank mother's occupation	0.0192		0.0190	0.0112	-0.0027	-0.0125
	(0.0155)		(0.0157)	(0.0141)	(0.0148)	(0.0160)
Rank father's occupation		0.1226***	0.1226***	0.1260***	0.1070***	0.1129***
		(0.0210)	(0.0209)	(0.0193)	(0.0190)	(0.0195)
Mother's age					-0.1034	-0.0387
					(0.1224)	(0.1258)
Father's age					0.0773	0.0914
					(0.1019)	(0.1065)
Mother employed					-1.1075	0.4540
					(1.2416)	(1.5809)
Father employed					0.6364	2.6121
					(2.2604)	(2.3148)
Mother intermediate schooling					0.7077	0.6125
					(1.4142)	(1.4064)
Mother high school					0.5955	0.5568
					(1.6223)	(1.5909)
Mother tertiary degree					-2.1632	-2.2416
					(1.5710)	(1.5490)
Father intermediate schooling					0.2406	0.3231
					(1.5991)	(1.6323)
Father high school					-2.6718	-2.4875
					(1.8445)	(1.8231)
Father tertiary degree					-1.1029	-0.8256
					(1.6224)	(1.6943)
Age 19						0.2304
						(3.0613)
Age 20						-1.9714
						(3.2131)
Age 21						-0.8613
						(3.1090)
Age 22						-4.1808
						(3.4716)
Age 23						-5.0019
						(4.0727)
Age 24						0.6510
						(4.2066)
Age 25						-13.1894***
						(5.0261)
2nd or higher born						-0.9391
						(1.0141)
Only child						0.6373
						(1.4450)
Grew up w. mother only						-2.1082
						(1.8578)
Grew up w. mother & stepfather						-8.1363***
						(2.9130)
Grew up w. other						-5.0976
						(4.2077)
Immigrant						-0.3772
						(1.5792)
Mother ln median income in occup.						-0.3280
						(0.2448)
Father ln median income in occup.						-1.2612**
						(0.5767)
Observations	3,540	3,540	3,540	3,540	3,540	3,540
R-squared	0.0004	0.0141	0.0145	0.0432	0.0473	0.0573
State FE	no	no	no	yes	yes	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Table 2.A.4: Full set of coefficients of baseline rank-rank regressions, daughters

Dependent variable	Daughters: Femininity rank major					
	(1)	(2)	(3)	(4)	(5)	(6)
Rank mother's occupation	0.0176		0.0185	0.0115	0.0242	0.0258
	(0.0148)		(0.0148)	(0.0147)	(0.0160)	(0.0165)
Rank father's occupation		-0.0452**	-0.0456**	-0.0517***	-0.0540***	-0.0547***
		(0.0192)	(0.0191)	(0.0180)	(0.0182)	(0.0183)
Mother's age					-0.0127	-0.0318
					(0.1213)	(0.1212)
Father's age					-0.0820	-0.0723
					(0.1004)	(0.1027)
Mother employed					1.4581	0.8289
					(0.9441)	(1.3499)
Father employed					-1.4892	-1.0373
					(1.8669)	(2.0525)
Mother intermediate schooling					1.7392	1.7473
					(1.2968)	(1.3004)
Mother high school					2.9125*	3.1032*
					(1.6489)	(1.6393)
Mother tertiary degree					3.3214**	3.4145**
					(1.6213)	(1.6192)
Father intermediate schooling					-1.2377	-1.2547
					(1.2461)	(1.2490)
Father high school					-2.1357	-2.1735
					(1.4909)	(1.5084)
Father tertiary degree					-1.8790	-1.7104
					(1.2893)	(1.3144)
Age 19						-1.1748
						(2.1898)
Age 20						0.6276
						(2.4425)
Age 21						2.1511
						(2.4837)
Age 22						3.9057
						(3.0181)
Age 23						0.5090
						(3.3832)
Age 24						0.5038
						(3.4642)
Age 25						4.0173
						(4.3015)
2nd or higher born						-0.2548
						(0.9035)
Only child						-0.9226
						(1.3420)
Grew up w. mother only						2.2100
						(1.4697)
Grew up w. mother & stepfather						0.9147
						(2.1832)
Grew up w. other						-4.8954
						(3.9111)
Immigrant						-1.0523
						(1.3615)
Mother ln median income in occup.						0.1231
						(0.2047)
Father ln median income in occup.						-0.1158
						(0.5621)
Observations	6,100	6,100	6,100	6,100	6,100	6,100
R-squared	0.0003	0.0018	0.0021	0.0289	0.0311	0.0344
State FE	no	no	no	yes	yes	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Table 2.A.5: Interactive effect of mother's and father's gender-typicality rank in occupation

Dependent variable	Gender-typicality rank in major			
	Sons		Daughters	
	(1)	(2)	(3)	(4)
Rank mother's occupation	-0.0245		0.0349	
	(0.0297)		(0.0281)	
Rank father's occupation	0.0981**		-0.0437	
	(0.0383)		(0.0354)	
Rank mother's x father's occup.	0.0003		-0.0002	
	(0.0006)		(0.0006)	
Dummy rank mother's occup. ≥ 50		-1.3343		2.5344**
		(1.0258)		(1.0406)
Dummy rank father's occup. ≥ 50		5.1224***		-0.8409
		(1.4820)		(1.5532)
Dummy mother's x father's rank ≥ 50		-0.5435		-1.7001
		(1.7883)		(2.0177)
Observations	3,540	3,540	6,100	6,100
R-squared	0.0574	0.0538	0.0344	0.0336
State FE	yes	yes	yes	yes
Parental characteristics	yes	yes	yes	yes
Individual characteristics	yes	yes	yes	yes
Parental income	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Table 2.A.6: Additional variations on the analysis sample

Dependent variable	Gender-typicality percentile rank in major							
Sample	All school leaving certificates		No teaching degrees		Biological parents only		No immigrant background	
	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rank mother's occupation	-0.0082	0.0199	-0.0058	0.0205	-0.0002	0.0253	-0.0079	0.0190
	(0.0146)	(0.0150)	(0.0167)	(0.0193)	(0.0167)	(0.0170)	(0.0166)	(0.0174)
Fank father's occupation	0.1031***	-0.0417**	0.0974***	-0.0440**	0.1054***	-0.0604***	0.1278***	-0.0619***
	(0.0175)	(0.0172)	(0.0212)	(0.0220)	(0.0197)	(0.0204)	(0.0219)	(0.0203)
Observations	4,341	6,748	2,715	3,387	3,218	5,502	3,063	5,266
R-squared	0.0663	0.0321	0.0657	0.0347	0.0552	0.0358	0.0649	0.0319
State FE	yes	yes	yes	yes	yes	yes	yes	yes
Parental characteristics	yes	yes	yes	yes	yes	yes	yes	yes
Individual characteristics	yes	yes	yes	yes	yes	yes	yes	yes
Parental income	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Table 2.A.7: Additional control variables

Dependent variable	Gender-typicality rank in major									
Sample	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rank mother's occupation	-0.0011	0.0256	-0.0147	0.0273	0.0026	0.0254	0.0037	0.0276*	-0.0156	0.0332*
	(0.0161)	(0.0160)	(0.0162)	(0.0167)	(0.0156)	(0.0163)	(0.0137)	(0.0154)	(0.0180)	(0.0185)
Rank father's occupation	0.1143***	-0.0543***	0.1071***	-0.0520***	0.1002***	-0.0532***	0.0956***	-0.0490***	0.1123***	-0.0536***
	(0.0194)	(0.0159)	(0.0193)	(0.0180)	(0.0196)	(0.0179)	(0.0181)	(0.0177)	(0.0194)	(0.0183)
High school GPA			5.3453***	-2.4343						
			(1.4722)	(1.5228)						
Relative math grade					2.2674***	-1.7327***				
					(0.1815)	(0.1712)				
Expected income							71.81***	-61.76***		
							(8.67)	(9.29)		
Mother inactive									-6.78	16.00
									(14.92)	(13.36)
Observations	3,538	6,092	3,529	6,092	3,491	6,001	3,540	6,100	3,540	6,100
R-squared	0.2040	0.1456	0.0703	0.0369	0.1317	0.0733	0.2536	0.1526	0.0574	0.0347
State FE	Landkreis	Landkreis	yes	yes	yes	yes	yes	yes	yes	yes
Parental characteristics	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Individual characteristics	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Parental income	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the gender-typicality percentile rank of sons'/daughters' university major. The key regressors are femininity percentile rank of mother's occupation and masculinity percentile rank of father's occupation. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. High school GPA (Abiturnote) can take values from 1 to 6, with lower values indicating better GPA. Relative maths grade is maths grade minus german grade, each taking values from 1 to 15, with higher values indicating better results. Expected income is obtained using earnings information by university major from the DZHW Graduate Panel Survey. Mother inactive is defined as the mother not having been employed since the individual was born. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office, DZHW Graduate Panel Survey.

Table 2.A.8: Probability to enter university (marginal effects after logit)

Dependent variable	Enters uni and has obtained general school-leaving certificate			
Sample	Sons		Daughters	
	(1)	(2)	(3)	(4)
Rank mother's occupation	-0.0004	-0.0002	0.0002	0.0008*
	(0.0004)	(0.0004)	(0.0006)	(0.0004)
Rank father's occupation	-0.0010**	-0.0000	-0.0022***	-0.0014***
	(0.0005)	(0.0004)	(0.0005)	(0.0004)
Mother intermediate schooling		0.0701***		0.0297
		(0.0222)		(0.0234)
Mother high school		0.0420		0.1787***
		(0.0280)		(0.0509)
Mother tertiary degree		0.0415		0.1924***
		(0.0369)		(0.0669)
Father intermediate schooling		-0.0171		-0.0395
		(0.0225)		(0.0325)
Father high school		0.1031***		0.0323
		(0.0359)		(0.0502)
Father tertiary degree		0.1010**		0.0013
		(0.0444)		(0.0491)
Observations	1,731	1,731	1,799	1,799
State FE	no	yes	no	yes
Parental characteristics	no	yes	no	yes
Individual characteristics	no	yes	no	yes
Parental income	no	yes	no	yes

Notes: Sample includes all students who participated in all survey waves, and are aged between 14 and 16 in grade 9 of secondary school. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: NEPS-SC4, Federal Labour Office.

Table 2.A.9: Categorical regressors for gender-typicality in parental occupation

Dependent variable	Sons: Masculinity rank major		Daughters: Femininity rank major	
	(1)	(2)	(3)	(4)
M: gender-atypical occup.	0.5547	0.8760	-1.9438**	-1.7412*
	(1.0252)	(1.0578)	(0.9709)	(0.9855)
M: gender-typical occup.	2.6533**	0.5136	-0.7957	-0.1433
	(1.1887)	(1.4445)	(1.0222)	(1.2131)
F: gender-atypical occup.	-6.7362***	-6.9068***	4.3331***	4.2126***
	(1.1232)	(1.0787)	(0.9775)	(0.9364)
F: gender-typical occup.	1.7773	0.6572	1.5384	0.6919
	(1.5748)	(1.5853)	(1.3211)	(1.2546)
Observations	3,540	3,540	6,100	6,100
R-squared	0.0195	0.0622	0.0053	0.0366
State FE	no	yes	no	yes
Parental characteristics	no	yes	no	yes
Individual characteristics	no	yes	no	yes
Parental income	no	yes	no	yes

Notes: Table shows estimates from OLS regressions. The dependent variable is the femininity percentile rank of daughters' university major. For the regressors, M indicates mother and F indicates father; the omitted category for regressors is gender-neutral (rank 31 to 69); gender atypical includes ranks 30 and lower; gender typical includes ranks 70 and higher. Parental characteristics include age, a dummy indicating the parent was employed when offspring aged 15, three dummies for parental educational level (each separately for mothers and fathers, respectively). Individual characteristics include two dummies for birth order, three dummies for family structure when growing up, and a binary variable indicating (1st or 2nd generation) immigrant background. Parental income is the natural logarithm of the median income in mother's and father's occupational group, respectively. Survey weights used. Standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Sources: NEPS-SC5, Federal Labour Office, Federal Statistical Office.

Chapter 3

Parental leave and attitudes towards gender roles

Abstract

In this paper, I study the effect of the 2007 paid parental leave reform in Germany on the gender role attitudes of parents; specifically, attitudes towards the (i) gender division of work, (ii) consequences of mothers' labour force participation for children's wellbeing, and (iii) fathers' appropriate roles. The new policy constituted a paradigm change in German family policy away from support for a gender-traditional division of work towards greater incentives for mothers' paid work and fathers' involvement in childcare. I compare the attitudes of parents with a child born in the two years before the reform (control group) to those with a child born within two years after the reform (treatment group). I find that the reform increased support for traditional gender roles for fathers, among parents affected by the reform compared to parents before the reform. This effect is driven by a change in the attitudes of men, and not women. I find no effect on the other two outcomes. These results are in line with exposure as well as norm-setting effects. Results also inform the broader literature on attitudinal change over the life course.

3.1 Introduction

Persistent differences in labour market outcomes between men and women remain but their size varies across countries. Such cross-country differences are largely driven by the behaviour of women at the transition to parenthood (Low & Sánchez-Marcos 2015). Indeed, the start of parenthood marks the beginning of increasing and lasting gender inequalities in earnings (Budig & Hodges 2010, Kleven et al. 2019).

Therefore, family policy, and in particular parental leave policy, plays an important role. Many high-income countries have implemented parental leave policies that actively support a more gender-equal division of work within the family over the last decade (Farré 2016). However, it remains unclear whether they are effective measures to produce more gender-equal outcomes, especially when looking at effects beyond the period of leave (Farré 2016, Olivetti & Petrongolo 2017).

One reason behind this may be that parenthood is surrounded by traditional attitudes and norms about the appropriate roles of men and women concerning the gender allocation of tasks (Grunow et al. 2007, Aisenbrey et al. 2009, Boll 2011, Schober 2013). Therefore, in order to achieve the desired outcomes, policy changes need to be accompanied by attitudinal changes (Farré 2016). This notion is supported by the growing literature that has established the relevance of gender role attitudes for labour market behaviour (Fortin 2005, Farré & Vella 2013, Platt & Polavieja 2016). What has been studied less is whether family policy can alter such attitudes. This gap in the literature remains despite the fact that gender role attitudes are important indicators of the social climate concerning gender equality (Blohm & Walter 2018).

In this paper, I study the impact of the 2007 paid parental leave reform in Germany on the gender role attitudes (GRA) of parents; specifically, attitudes towards (i) the gender division of work, (ii) the consequences of the labour force participation of mothers for children's wellbeing, and (iii) fathers' appropriate roles. This policy change constituted a paradigm change in German family policy away from support

for a gender-traditional division of work towards greater incentives for women's paid work and father's involvement in childcare (Lewis et al. 2008, Schober 2014).

The reform replaced a means-tested, small flat benefit aimed at parents below a certain income threshold with an unconditional earnings-related benefit providing a percentage of earnings while shortening the benefit duration from 24 to 12 months. The reform also introduced an additional two months of benefits to couples in which each parent takes at least two months of leave. The resulting policy created strong incentives for fathers to take two months of leave that would have otherwise been lost. Consequently, it also provided incentives for fathers to get more involved in childcare and home-production tasks.

The reform constitutes a natural experiment because all parents with a child born on or after January 1, 2007 were eligible for the new benefit and the reform was introduced relatively quickly and unanticipated (Kluve & Schmitz 2018). To estimate the effect of the reform on attitudes of parents in the medium term, I use nationally representative data from the 2012 and 2016 German General Social Survey (ALLBUS). I compare the attitudes of parents with a child born in the two years before the reform (control group) to those with a child born within two years after the reform (treatment group). Parents' attitudes in both groups are recorded at the same time and several years later, ensuring that both groups faced the same macroeconomic, institutional, and cultural contexts. I conduct various robustness checks to ensure that endogenous selection into treatment is not driving results.

Germany furnishes an interesting context for this paper as it is a country with relatively conservative gender norms, especially when it comes to the compatibility of motherhood and work (Lewis et al. 2008). Historically, (West) German family policy has favoured the male breadwinner model, wherein men work and women take care of household and children (Bauernschuster & Rainer 2012). The 2007 reform constitutes a turning point in family policy by providing options for a more equal sharing of responsibilities that were not previously available (Lewis et al. 2008).

Existing research argues that the new policy led to the emergence of a new social norm in which mothers return to work after 12 months (i.e. quicker than before)

and fathers take two months of parental leave (instead of none) (Unterhofer et al. 2017, Cygan-Rehm et al. 2018). This constitutes a move towards a more equal gender division of leave albeit with mothers taking most of the leave and often returning to work part-time. On the one hand, given the significant policy change, one may expect that the reform also modernised parents' attitudes towards the appropriate roles of men and women more generally. On the other hand, the new benefit may reinforce traditional attitudes as mothers still take the bulk of the leave and return to work part-time more often. Indeed, the reform incentivised paternal childcare involvement but not gender equality within the family more generally (Schober 2014). Yet another view is that attitudes are formed early in life and remain fairly stable after reaching adulthood, in which case the reform should not have any effect on gender role attitudes (e.g. Krosnick & Alwin 1989). Thus, the question of whether the reform modernised gender role attitudes warrants empirical investigation. However, this has not been analysed in existing research.

Contrary to what one might at first expect, I find that the reform increased support for traditional gender roles for fathers among parents affected by the reform, compared to parents before the reform. I find no effect on the other two outcomes: attitudes towards the gender division of work, and attitudes towards the consequences of the labour force participation of mothers. I also find that the reform did not impact reported sharing of household and childcare activities. The effect on increased support for traditional gender roles for fathers is driven by a change in attitudes of men, and not women.

These results are robust to a number of robustness checks, paying particular attention to the representativeness of the analysis sample and the possibility of endogenous fertility. Checks include variations in the window of treatment and control groups, the exclusion of births closely around the implementation of the reform, additional control variables, placebo reforms, and accounting for birth order, as well as balancing checks.

The failure of the reform to modernise attitudes of those directly affected by the new benefit suggests that the policy changes may not have gone far enough to trigger

deeply rooted, fundamental changes in gender role attitudes. In particular, while the reform incentivised fathers' leave-taking and mothers' return to work, by no means did it incentivise a gender-egalitarian household model. It may have thereby cemented traditional beliefs in a modified way.

However, failure to identify an effect of the reform on attitudes of those eligible for the new benefit does not rule out the possibility that the reform played part in a more gradual change in attitudes. While difficult to identify empirically, it is possible that the reform led to a modernisation of attitudes in society at large, and not just of those directly affected by the new benefit. Attitudinal change may be mediated through the normative messages surrounding the reform and transmitted via the media and behaviour of peers and friends rather than direct own experience. Indeed, as I show in a descriptive analysis, overall societal attitudes towards gender roles have gradually and continually modernised over the last twenty years.

The finding that the reform made men's attitudes towards the appropriate role of fathers more traditional is in line with both exposure as well as norm-setting policy feedback effects. For example, being offered the new benefit may have made fathers aware of work-care conflicts, both through their own experience from leave-taking as well as through the normative messages that the new policy carried. Mothers, on the other hand, were already taking leave before the reform and hence they did not have new experiences to the same extent that would have changed their identities.

This paper makes three contributions: First, it improves our understanding of the policy feedback effects of parental leave policies on the gender role attitudes of parents by providing the first analysis of the impacts of the 2007 parental leave reform on parental attitudes. Second, it adds to the empirical literature on the effects of the German reform by providing a potential mechanism for the economic effects that previous research has identified. In particular, the fact that the reform did not lead to a modernisation in attitudes may explain prior findings in the literature that the reform was successful in achieving increased leave-taking among fathers and a quicker return to work among mothers but did not lead to significant changes regarding gender equality in paid and unpaid work. Third, results from this

paper inform the broader literature on whether individual attitudes change over the life course, by suggesting that impressionability may not always run in the 'right direction'.

The remainder of the paper is organised as follows. Section 3.2 details the institutional context and describes the parental leave reform in Germany. Section 3.3 discusses the relevant literature on parental leave and attitudinal change. Section 3.4 outlines the empirical strategy and data. Section 3.5 contains the results including various robustness checks and heterogeneity analyses. The final section provides a discussion of the findings and concludes.

3.2 The 2007 paid parental leave reform in Germany

Parental leave policies are a central pillar of family policy and their design can play an important role in shaping gender differences in the labour market and in the household (Sjöberg 2004, Farré 2016). Today, most high-income countries have in place gender-neutral parental leave policies that either mothers or fathers can take (Olivetti & Petrongolo 2017). In addition, the majority of European countries have introduced parental leave entitlements reserved exclusively to fathers over the last decade, known as paternity leave or 'daddy quota' (Farré 2016). Daddy quotas are designed to increase the involvement of fathers in childcare and housework activities. Given that women shoulder a disproportionate share of housework and that housework negatively impacts wages (Bryan & Sevilla 2011), daddy quotas may facilitate women's opportunities in paid work and promote gender equality in the labour market and at home (Farré & González 2019, Patnaik 2019).

For a long time, (West) German family policy promoted a traditional male breadwinner model in which men do paid work and women focus on household and childcare activities (Bauernschuster & Rainer 2012).[1] Means-tested parental benefits

[1]While policy in the former German Democratic Republic supported a dual-worker model, after reunification the behaviour of East German mothers adapted to that of West German mothers not

called 'child-rearing money' (Erziehungsgeld) were in place from the mid-1980s. Before 2007, the parent taking leave received a flat rate of 300 Euro per month paid for up to 24 months after childbirth if family income did not exceed a certain threshold.[2] These incentives combined with traditional gender norms, particularly with regards to the compatibility of motherhood and work, meant that mothers took relatively long work interruptions (Bergemann & Riphahn 2015) and almost no fathers took parental leave (Tamm 2019).

In 2007, this changed when a new parental leave benefit called 'parents' money' (Elterngeld) was enacted. The reform constitutes a paradigm change in family policy towards greater incentives for mothers' employment. Given the relatively conservative gender role attitudes in international comparison, "Germany appeared to be taking a more radical lead in a contested policy area" (Lewis et al. 2008, p.276). While attitudes towards gender roles have gradually become less traditional since the 1980s (Blohm & Walter 2018), the introduction of the reform was not perceived to have followed changes in gender norms. On the contrary, given a population that used the term 'raven mother' to highlight that working women neglect their children, the reform was considered premature by some (Geisler & Kreyenfeld 2019).

Under the new policy, all parents with a child born on or after the 1st of January received the new benefit Elterngeld. The reform entailed several changes: (i) the benefit period was shortened to up to 14 months; (ii) means testing was abolished; (iii) the new benefit was earnings-related, replacing 67 percent of net earnings of the parent taking up the leave, with a set minimum of EUR 300 and a maximum of EUR 1,800; (iv) two of the 14 months of leave were exclusively reserved for fathers and non-transferrable to mothers.[3] Given that each parent took at least two months of leave, couples were granted the 14 months. Otherwise, the two additional months

to return to the labour market after childbirth (Hanel & Riphahn 2011).

[2]Around 66 percent of parents received this benefit. Alternatively, parents could choose to receive a benefit of 450 Euro per month for a period of up to 12 months. This alternative was chosen by a minority of 10 percent of parents. 24 percent of parents were not eligible for the benefit as their family income exceeded the maximum threshold (Kluve & Tamm 2013).

[3]Parents could choose to receive half of the benefit amount for a period of 24 months but only about ten percent of recipients chose this option (Statistisches Bundesamt 2013). Single parents receive 14 months of leave. The job protection period remained unchanged at three years.

were lost. Apart from the requirement of two months' minimum leave, couples could freely choose how to split the leave. For example, they could use it simultaneously, subsequently, or a mix of the two.

The reform had several aims. It intended to facilitate taking care of the own child in the first year after childbirth. It also aimed to provide financial independence to each parent, and to encourage a timely return of mothers to the labour force (i.e. after 12 months). Finally, it was designed to increase fathers' leave-taking and involvement in childcare (Huebener et al. 2016).

Given these aims, the reform may have carried implicit normative messages of shared parenting responsibilities and gender equal division of paid and unpaid work (Schober 2014). The Federal Ministry for Family Affairs, Senior Citizens, Women, and Youth (BMFSFJ) ran a large advertising campaign, raising awareness for the introduction of Elterngeld (Unterhofer et al. 2017). This included billboards saying "I learn crawling with mum. Then I learn walking with dad." According to Unterhofer et al. (2017), the guiding principle behind this text was a model in which the mother first takes parental leave, often for a year, followed by the father taking a much shorter leave, often for the minimum duration of two months.

From the growing literature on the effects of the policy reform we have learned that the main goals were largely met. That is, the reform successfully smoothed household income in the first year after childbirth (Geyer et al. 2013), accelerated mothers' return to work (Bergemann & Riphahn 2015), and increased the share of fathers taking leave from around 2.5 percent before the reform to 15 percent in 2007 (Cygan-Rehm et al. 2018), thereafter gradually increasing each year to 39 percent in 2016 (Statistisches Bundesamt 2020). In so doing, several authors argued that a new social norm emerged in which mothers return to work after 12 months of leave and fathers take 2 months of leave (e.g. Bergemann & Riphahn 2015, Unterhofer et al. 2017, Cygan-Rehm et al. 2018). Such a social norms interpretation is supported by the existence of peer effects in leave-taking (Welteke & Wrohlich 2019). Overall, these changes in behavioural patterns highlight that the reform was successful, especially given the relatively conservative context.

However, evidence on the reform's effects on the division of labour within the family are mixed. For example, as of 2016 the share of fathers taking parental leave remained below 40 percent while over 90 percent of mothers took leave. Moreover, the majority of fathers continues to take the minimum of two months while most mothers take around 12 months of leave (Samtleben et al. 2019). While the new benefit increased mothers' employment probability in the second year after childbirth and beyond, this is primarily driven by increases in part-time employment (Kluve & Schmitz 2018). Finally, evidence on fathers' involvement in and the division of childcare and housework tasks among partners is mixed. While some find no effects of the reform on fathers' time devoted to childcare in the first 12 months after birth (Kluve & Tamm 2013), others find support for increases in some aspects of unpaid work (Schober 2014, Tamm 2019). Overall, a modified male breadwinner model continues to dominate, in which fathers tend to work full-time and mothers part-time while doing the majority of childcare and household tasks (OECD 2016).

These findings are broadly in line with international evidence on the economic effects of parental leave policies, showing that leave duration has first-order effects on mothers' return to work decision but no consensus has emerged concerning its effects on outcomes such as female employment, earnings, and fertility (Farré 2016, Olivetti & Petrongolo 2017). While daddy quotas are an effective measure to increase fathers' take-up of leave, few fathers take more leave than the minimum amount specified and their ability to increase the long-term participation of fathers in domestic work and childcare has not been confirmed in most countries (Ekberg et al. 2013, Farré 2016, Dunatchik & Özcan 2019, Patnaik 2019).

Given that cultural norms play an important role in the division of paid and unpaid work among parents, it is not surprising that parental leave policies produce mixed results. The effects of the Elterngeld in Germany may have been limited by traditional attitudes and practices (Lewis et al. 2008, Schober 2014). A more gender-equal division of roles also requires a change in attitudes towards gender roles in paid and unpaid work (Farré 2016). It is unclear whether family policy also changes attitudes. Therefore, the literature on the relationship between family

policy and attitudinal change will be explored in the next section.

3.3 Parental leave and attitudinal change

Historically, the gender division of labour was characterised by a male breadwinner norm in which fathers work full-time and mothers take care of the home and children. Such a work division within families is guided by a large cultural component (Farré 2016). That is, it is deeply rooted in social norms concerning the appropriate roles of men and women. Support for this notion is provided by research which shows that less traditional attitudes towards the gender division of work strongly predict female labour force participation and earnings across countries (Fortin 2005). Therefore, a more equal sharing of responsibilities requires a change in attitudes towards the appropriate roles of men and women in society (Farré 2016). Policy incentives may need to be accompanied by attitudinal changes to achieve a more gender egalitarian division of work. This raises the question how such attitudes change.

Attitudinal change

There are two main views about attitudinal change. One suggests that gender role attitudes are formed early in life and remain fairly stable over the remaining life course (Krosnick & Alwin 1989, Brooks & Bolzendahl 2004). It is assumed that attitudinal change happens primarily via cohort replacement (e.g. Brewster & Padavic 2000, Inglehart & Baker 2000). Such a view gives little weight for the potential of policy reforms to impact individual attitudes.

A second view assumes that changes in the social structure or individual circumstances can alter an individual's attitudes over the life course, even after reaching adulthood (Brooks & Bolzendahl 2004, Baxter et al. 2015). Recent studies show that individuals' attitudes are susceptible to life events such as becoming parents (Schober & Scott 2012, Baxter et al. 2015), parenting school-age daughters (Borrell-Porta et al. 2019) and migrating (Breidahl & Larsen 2016), therefore providing support to this view. Such an approach also supports the notion that policy reforms

can trigger attitudinal change. However, there is little evidence to date on whether policy reforms can lead to individual changes in gender role attitudes in the short to medium term.

Previous studies on the impact of policy on attitudinal changes

Several studies have emphasised the role of culture and policy institutions for shaping (both stated and revealed) preferences regarding gender roles and female labour force participation (e.g. Fernández & Fogli 2009, Bauernschuster & Rainer 2012, Alesina et al. 2013, Beblo & Görges 2018). While "culture and institutions [are thought to] interact and evolve in a complementary way, with mutual feedback effects" (Alesina & Giuliano 2015, p. 938), these studies emphasise the slow and steady process of their role in shaping preferences and attitudes, as well as their persistence over the long term.

In line with this, at the cross-country level, respondents in countries or political regimes with more gender-equal family policies have more positive attitudes towards female labour force participation (Sundstrom 1999, Sjöberg 2004, Bauernschuster & Rainer 2012). However, when considering solely the generosity of parental leave provisions (as one pillar of family policy), there is no clear cross-country association with gender role attitudes (Olivetti & Petrongolo 2017).

At the national level, the introduction of parental leave policies is often accompanied by or has followed changes in a country's gender social norms (Olivetti & Petrongolo 2017). Only a few studies have examined the impact of specific family policy changes on attitudes at the micro level. These have produced mixed results and no consensus has emerged. For example, the introduction of daddy months in Norway had no effect on parents' attitudes towards gender roles but led to lower levels of reported conflicts over the household division of labour and a more equal division of some household tasks (Kotsadam & Finseraas 2011). Another study focused on Norway found that the increase in childcare availability was associated with a significant shift in mother's attitudes towards the suitability of institutional care (Ellingsæter et al. 2017). Pedulla & Thébaud (2015) conduct a survey experiment

in which respondents are asked about their preferred relationship structure under varying degrees of institutional constraints. The results show that young adults' preferences are responsive to work-family policy interventions and that most people prefer an egalitarian relationship structure if institutional constraints are removed. Gangl & Ziefle (2015) study several extensions in parental leave entitlements in Germany during the 1990s and early 2000s. They find that more generous leave entitlements led to a decline in mothers' subjective work commitment. Unterhofer & Wrohlich (2017) show that the 2007 parental leave reform changed grandparents' gender role attitudes. Specifically, mothers of sons who took parental leave expressed lower levels of agreement with a traditional gender division of work.

Moreover, attitudinal change can also run in the unintended direction. In Germany, a recent study looked at the expansion of public childcare and found that it had contradictory effects: While childcare expansion has been associated with less traditional gender role attitudes among mothers in West Germany, it was associated with more traditional attitudes among East German mothers (Zoch & Schober 2018). Another example of unintended consequences, while not focusing on gender role attitudes is a recent paper by Farré & González (2019). It shows that the introduction of two weeks of paternity leave in Spain did not only lower subsequent fertility but also lowered the desired fertility reported by men. To date, there is no evidence on whether the 2007 German parental leave reform altered parents' gender role attitudes.

Mechanisms of attitudinal change

The idea that family policy reforms can trigger shifts in individual attitudes is in line with the concept of policy feedback effects. Policy feedback effects occur when policy changes lead to attitudinal changes through the feedback effects that new policies create on the society which they have originated from (Svallfors 2010). The literature distinguishes between two mechanisms through which policy reforms can alter attitudes: direct exposure effects on the one hand, and norm-setting effects on the other hand (e.g. Sjöberg 2004, Gangl & Ziefle 2015, Zoch & Schober 2018).

According to exposure effects, the direct exposure to a new policy can lead to attitudinal change (Gangl & Ziefle 2015). Policy feedback effects that operate via direct exposure mechanisms are expected to be limited to those who are directly affected by a policy change. Similar to theories of exposure, according to identity theories (e.g. Stryker & Burke 2000), novel experiences such as a father's leave-taking or a mother's breadwinning may change their gender role identities. For example, increased exposure to childcare and domestic tasks may strengthen men's parenting identities and practices (Schober 2014). On the other hand, it may also make fathers realise the opportunity costs of taking leave and they may experience conflicts between work and care they were previously unaware of. In the context of the 2007 parental leave reform, both exposure and identity theories would predict that parents with a child born on or after 1 January 2007 may change their attitudes in response to the new benefit, as they were directly affected by it (as opposed to parents who had a child born before 2007). In addition, the change in experience was more pronounced for fathers compared to mothers as most mothers already took parental leave before the introduction of the new policy. This suggests that we would expect fathers to be more likely to change their attitudes in response to the policy change compared to mothers. In addition, we would expect individuals who are more likely to use the new benefit to be more likely to change their attitudes, for example, highly-educated fathers compared to fathers with lower levels of education.

Beyond exposure effects on those who are directly affected by a policy, policies may affect attitudes in society at large through norm-setting effects. This is because, apart from providing economic incentives and shaping opportunities, family policy contains normative messages which influence views regarding the appropriate roles of men and women in the gender division of work (Lewis 2001, Sjöberg 2004). Thus, policy changes the legitimacy of certain behaviours.

Family policy may therefore set new normative anchors for the trade-offs between men's and women's work and care roles (Gangl & Ziefle 2015). Indeed, several authors have argued that the 2007 parental leave reform led to the emergence of a new social norm in which mothers return to work after 12 months of leave and

fathers take two months of leave (e.g. Bergemann & Riphahn 2015, Unterhofer et al. 2017, Cygan-Rehm et al. 2018). If norm-setting effects play a role in explaining attitudinal changes in response to the 2007 reform, we would expect to see changes in attitudes both among mothers and fathers, and both among those who were eligible for the new benefit as well as parents with older children who were not eligible for the benefit.

However, the two mechanisms of exposure and norm-setting policy feedback effects cannot be considered entirely independent from each other. For example, *being offered* the new benefit may affect parental attitudes even if a parent does not actually use the leave (Kotsadam & Finseraas 2011). Eligible parents were directly exposed to important norm-setting signals that the new benefit carried (Hook 2010). While non-eligible parents of children born before 2007 would also learn about the new benefit and its accompanying norms, only eligible parents had to actively engage with the new benefit in terms of its implications on their own decision-making. Specifically, each parent had to decide whether to make use of paid parental leave and couples had to decide how to split the leave among themselves. Even if a couple ends up deciding to not make use of the daddy months, they will have gone through that decision-making process, as opposed to non-eligible parents or society at large. Therefore, we would expect any norm-setting effects to be strongest among those who are eligible for the benefit. It is hence not possible to attribute any changes in attitudes of parents eligible for the new benefit to either direct exposure or norm-setting effects. Instead, it is reasonable to assume that both mechanisms play a partial role in explaining any observed changes in parental attitudes.

3.4 Data and methods

3.4.1 Data sources and sample

The paper uses data from the 2012 and 2016 German General Social Survey (Allgemeine Bevoelkerungsumfrage/ALLBUS). The ALLBUS survey is a repeated cross-

section collected biennially and comprising a sample of around 3,500 respondents per survey year (GESIS - Leibniz-Institut für Sozialwissenschaften 2019). It is based on a sample of individuals representative of the adult population living in Germany (Wasmer et al. 2014). The survey covers a rich range of questions on attitudes, political preferences, etc. The advantages of this dataset include the items on gender role attitudes and the availability of month of birth of all children in the household, both which are key for the paper.

Gender role attitudes are covered in every second survey wave, and to date this includes the post-Elterngeld reform survey years 2008, 2012, and 2016. In 2012 and 2016, a new set of questions on gender role attitudes was given to half of survey respondents, taking into account the changing gender relations and partly replacing previous attitude questions that were considered outdated (see Walter 2018*b*). I refer to this part of the sample as the 'new GRA split'. The new set of questions are of particular interest for this paper as they contain some items specifically on the changing roles of fathers. In the main analysis, I only consider the respondents who were asked the new set of questions to ensure coherence and that outcome variables are the same across the full analysis sample. For robustness, for the three attitude items that were part of both the old and new set of questions, I also perform analyses that include all survey respondents in 2008, 2012, and 2016, not just the new GRA split.

The sample is restricted to parents who had a biological child born between January 2005 and December 2008 and whose children live in the same household. I also drop a small number of observations on foreign-born respondents who migrated after 2004 and observations for which month of birth is missing. The final sample consists of 185 respondents. Of those, 66 are in the control group and 119 are in the treatment group. The treatment group is larger than the control group. The main reason is that for parents who had a child born during both the control and treatment window, the lastborn child is considered and hence they are considered treated. However, robustness checks considering only the lastborn child show that this does not affect results.

To make sure the analysis sample is not a selected sample, Table 3.1 sheds light on its representativeness. To this end, the table compares characteristics of the analysis sample to those of a larger comparable group, which includes all respondents who had at least one child between 2004 and 2009 and whose age was in the same range as range of the analysis sample (between 21 and 55 years). The table shows that there are no significant differences between the two samples in terms of observable characteristics, minimising concerns of selectiveness of the analysis sample.

Table 3.1: Representativeness of the analysis sample

	Analysis sample	Larger comparable sample	Difference significant
Age	39	39.9	
Number of children	2.1	2	
Age at first birth	29.1	29.8	
Female	0.59	0.57	
Tertiary education	0.45	0.41	
Married	0.78	0.79	
Lives with partner	0.92	0.9	
Employed	0.8	0.83	
Foreign born	0.17	0.15	
Lives in East Germany	0.14	0.15	
Number of observations	185	462	

Notes: This table shows whether there are any significant differences in covariates between the analysis sample and a larger comparison sample. The analysis sample consists of those who have a child born between 2005 and 2008 and who were part of the survey split administered the new items on gender role attitudes. The comparison sample comprises all respondents interviewed in 2012 or 2016 who had at least one child between 2004 and 2009 and whose age was in the same range as that of the analysis sample (between 21 and 55) but who are not part of the analysis sample. Survey weights used. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Previous research has identified persistent differences in gender roles attitudes between West and East Germany (e.g. Bauernschuster & Rainer 2012). Due to the small sample size in particular of those living in East Germany, I include both East and West Germany in the sample rather than presenting results separately. However, I present results from a heterogeneity analysis studying whether effects vary across residents in East and West Germany. Moreover, I include a full set of results for West Germany in Appendix 3.A.

3.4.2 Methods

The introduction of the Elterngeld constitutes a natural experiment as it quasi-randomly assigns all parents with a child born closely around January 1, 2007 to a treatment and a control group. Specifically, all parents with a child born on or after the 1st of January were eligible for the new benefit Elterngeld and thus form the treatment group. All parents with a child born before the cutoff date fall under the old Erziehungsgeld scheme and form the control group.

I therefore follow previous research on the impacts of the policy change (e.g. Kluve & Schmitz 2018, Cygan-Rehm et al. 2018) and estimate the effect of the reform by comparing treatment and control groups. Specifically, I compare gender role attitudes of parents who had a child in the 24 months before (control group) to those of parents who had a child in the 24 months after the introduction of the reform (treatment group), to identify the reform's effect on parents' gender role attitudes in the medium term. Importantly, attitudes of the treatment and control groups are measured at the same time and several years after the reform, thereby ensuring that both groups face the same macroeconomic, institutional, and cultural environments. This is illustrated in Figure 3.1.

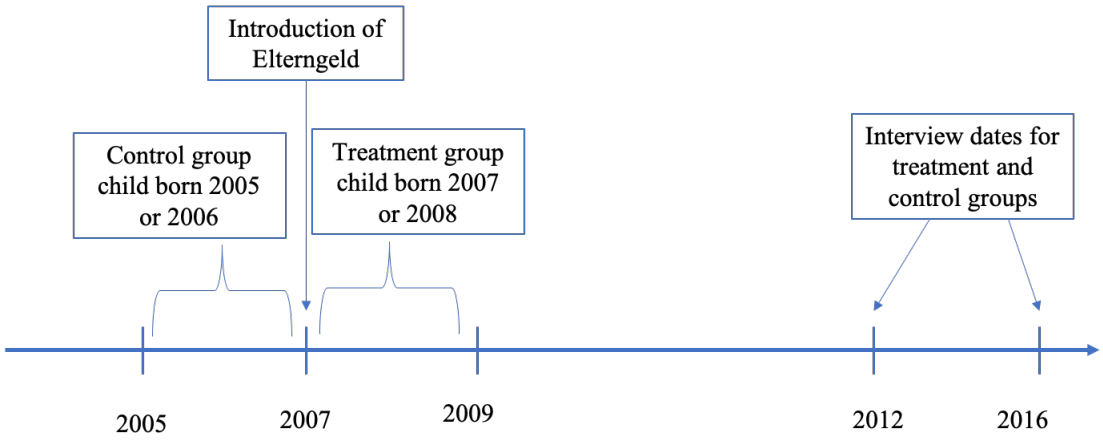

Figure 3.1: Treatment and control groups and the timing of interviews

Source: Author's illustration.

I estimate the following regression model via OLS:

$$y_i = \alpha + X'\beta + \gamma \text{Elterngeld benefit}_i + \varepsilon_i \tag{3.1}$$

where y_i is the outcome of interest, X_i is a vector of control variables including respondents' age and square of age, child's age and square of age, and birth month fixed effects. γ is the coefficient of interest and measures the treatment effect of eligibility for the new benefit. I estimate OLS regressions with robust standard errors, but I also show results from ordered probit models for robustness. All regressions are estimated with the provided survey weights that adjust for oversampling of East German federal states.

The paper is interested in getting as close as possible to estimating the causal effect of the policy reform on parental attitudes. However, fathers who took parental leave are a selected group who differ from fathers who were eligible but did not opt to take parental leave in terms of both observed as well as unobservable characteristics. For example, highly-educated fathers are most likely to take parental leave (Geisler & Kreyenfeld 2019), and educational level has been found to be systematically related to attitudes towards gender roles (e.g. Kotsadam & Finseraas 2011, Bauernschuster & Rainer 2012). Similarly, mothers' and fathers' leave duration and how couples choose to split leave among them is likely to be related to the attitudes they hold. Therefore, serious concerns around self-selection prevent using benefit take-up as an independent variable when interested in estimating the effect of the policy reform.

A preferrable alternative is therefore to use benefit eligibility as a key regressor (intention to treat). This intention to treat (ITT) effect identifies the overall effect of the reform on those eligible, independently of their benefit take-up or duration of leave. This is preferable because there are no issues of self-selection into the take-up of parental leave. For this reason, estimating the ITT effect is the standard approach in related literature on parental leave reforms, for example, when estimating the effect of parental leave on fertility (Farré & González 2019), on attitudes in the grandparents' generation (Unterhofer & Wrohlich 2017), or on families' living arrangements (Cygan-Rehm et al. 2018). In fact, ALLBUS data does not even con-

tain information on parental leave uptake. From the perspective of policymakers, the intention to treat effect is arguably more relevant than the effect on those who took up leave as it estimates the total effect of the reform (Kotsadam & Finseraas 2011).

Since benefit take-up of mothers is nearly universal, the results suggest effects on the treated (those who actually took the leave) that are nearly identical to the ITT estimates (Samtleben et al. 2019). For fathers, the ITT effect can be interpreted as lower bound estimates. As around 15 and 21 percent of eligible fathers took up the benefit in 2007 and 2008, respectively, results suggest effects on the treated up to five times as large as the ITT estimates if direct exposure to benefit take-up was solely driving any results. However, it is reasonable to expect that *being offered* paid parental leave specifically reserved to fathers affects the attitudes of eligible parents "over and above the effects of actually using the leave" (Kotsadam & Finseraas 2011, p. 1614). This is because the introduction of leave specifically reserved to fathers is a strong norm-setting signal which challenges norms of male breadwinning and encourages fathers to be more involved in childcare (Hook 2010). While norm-setting policy effects also affect those who are not eligible for the benefit (i.e. parents in the control group), it can be expected that eligible fathers in the treatment group are more strongly experiencing them compared to non-eligible fathers in the control group. For example, eligible couples have to actively engage with and decide how they split the leave among themselves. Even if a couple ends up deciding to not make use of the daddy months, they will have gone through that decision process, as opposed to parents in the control group. As a result, a limitation of the ITT approach in this context is that it does not allow attribution of any effects to the different underlying mechanisms described in Section 3.3. Instead, it is reasonable to assume that both mechanisms play a partial role in explaining any observed changes in parental attitudes.

The main threat to identification is endogenous selection into treatment. Specifically, the characteristics of parents who chose to have a child under the new benefit regime may differ from those who became parents given the pre-reform benefits.

Similarly, the reform may have altered preferences for having additional children. Since the reform was largely unanticipated and passed very quickly, parents with children born within three months before and after the eligibility cutoff could not know that the reform would be in place at the time their children were conceived (Kluve & Schmitz 2018). Thus, by comparing outcomes of parents who had a baby just before to those who had a baby just after the reform, it is possible to identify the causal effect of the reform.

Ideally, I would compare parents who had a child in the three months before the reform to those who had a child in the three months after the reform so that endogenous selection into treatment is not possible (e.g. Kluve & Schmitz 2018). Additionally, to rule out potential seasonal effects, I would combine a short window of births with a difference-in-differences strategy (e.g. Dustmann & Schönberg 2011). That is, I would compare attitudes of those with children born shortly before and shortly after the reform on the 1st of January 2007 to those born shortly before and after the 1st of January in the years before and after, when no policy change took place.

Unfortunately, due to the small sample size resulting from the selection criteria, I cannot follow a difference-in-differences strategy. Instead, I need to increase the window around the cutoff to 24 months before and after the reform, yielding a sample size of 185 respondents. The choice of window around the cutoff date highlights the tradeoff between increasing sample size and making treatment and control groups as similar as possible while reducing the likelihood of endogenous fertility. To ensure that endogenous selection into parenthood is not driving the results, I perform various robustness checks and sensitivity analyses. I conduct balancing tests to confirm that characteristics of the treatment and control groups are not significantly different from each other. Additionally, I vary the window of births for inclusion in treatment and control groups, I include additional control variables, I show that treatment does not predict total fertility, and I study results for different birth order parities and a subsample of parents who have one child only. Results are robust to these checks and thus increase confidence in the findings, despite the

limitations I discussed.

Using a 24 month window before and after the reform, I consider all individuals who had a child born between January 2005 and December 2008. For those who had more than one child in this period, I consider the lastborn child. This follows previous research (Bergemann & Riphahn 2011). Parents who had a child prior to 2007 and the next child post 2008 are not considered. In robustness checks, I instead consider the lastborn as well as the firstborn child, respectively, for the assignment to treatment and control groups. The results stay qualitatively similar.

Another concern is that mothers who are due to give birth closely around the reform cutoff date may time their birth, for example through induced births or caesarean sections. Therefore, in a robustness check, I exclude parents who had a child in the month around the introduction of the new reform. Potential seasonal effects pose an additional threat to identification. That is, previous research has shown that children who are born in spring have different long-term outcomes from children born in the fall (e.g. Buckles & Hungerman 2013). However, this should be less of a concern as the seasonal effect operates mainly through relative age imposed by school enrolment cutoff dates based on birth month. Therefore, it is less of a concern for parents' long-term attitudes. Nevertheless, I control for child's month of birth.

Finally, my identification strategy relies on the fact that parents in both treatment and control groups are interviewed at the same time. For this reason, any macroeconomic or policy changes apart from the 2007 parental leave reform, or any trends in social norms should not bias my results. In particular, there were two subsequent changes in family policy. One was an expansion of public child-care provision for children aged younger than three. A second one was the introduction of Elterngeld Plus in 2015, which facilitated parents' ability to work part-time while receiving parental leave benefits. It also granted additional leave of at least four months for couples in which both parents work 25 to 30 hours a week (Samtleben et al. 2019). Such policy changes would affect the medium-term attitudes held by treatment and control groups in similar ways, thus not threatening the identification

strategy. Following the same logic, the fact that parental leave policies are often accompanied by or follow changes in gender social norms (Olivetti & Petrongolo 2017) does not threaten my identification strategy.

3.4.3 Measures

Gender role attitudes encompass beliefs about "the assignment of different adult social responsibilities to men and women" (Pleck 1977, p.182). Six gender role attitude items have been asked in ALLBUS since 1982. These were developed in the 1970s and 1980s and primarily focus on a traditional male breadwinner model (Walter 2018*b*). Similarly, the measures used in representative international surveys tend to focus on a traditional male breadwinner model and questions that consider the changing role of fathers in the family are generally not included (Walter 2018*a*). Against this background, a novel set of questions was introduced to ALLBUS in 2012. In 2012 and 2016, half of respondents in the new GRA split were asked a new set of nine items, which include three of the old items and six new ones. The new questions reflect the social changes of the past decades with regards to the employment of women with young children, the decrease of the male breadwinner role and the increase of co-parenting (Walter 2018*b*). Therefore, the new set of items is supplemented with statements concerning the role of fathers and a more egalitarian division of tasks among couples. These nine items are shown in Table 3.2.

Walter (2018*b*) details the revision and validation of the new ALLBUS items. Results from confirmatory factor analysis reveal that the revised measure consisting of the nine items presented in Table 3.2 showed a satisfactory structure with two factors, one representing traditional gender roles and the other representing modern and more egalitarian gender roles.[4] Given the novelty of the measures concerning the appropriate role of fathers in particular, such validation is crucial for their in-

[4]An alternative item, the statement "The best way to organise family and work life is for both partners to work part-time and to look after the home and children equally" was found to not be strongly correlated with the new factor modern gender roles and was therefore not considered for inclusion into the new measure.

terpretation. Consequently, these items on fathers' roles have been presented and interpreted on a traditional-modern spectrum in the literature, similar to the items on mothers' roles (see e.g. Blohm & Walter 2018).

Table 3.2: Gender role attitude items in ALLBUS

Item name	Item text	Index topic	Agreement considered as
bothfull	The best way to organise family and work life is for both partners to work full-time and to look after the home and children equally.	Division of tasks	modern
malebread	It is much better for everyone concerned if the man goes out to work and the woman stays at home and looks after the house and children.	Division of tasks	traditional
workmumhome	Even if both parents work, it is still better if the mother has main responsibility for looking after the home and children.	Division of tasks	traditional
fullmumbond	A mother working full-time can normally establish just as close a relationship with her small child as a mother who doesn't work.	Mothers' LFP	modern
childbenefits	A child actually benefits from his or her mother having a job rather than just concentrating on the home.	Mothers' LFP	modern
childsuffers	A small child is bound to suffer if his or her mother goes out to work.	Mothers' LFP	traditional
fulldadbond	A father working full-time can normally establish just as close a relationship with his small child as a father who doesn't work.	Fathers' role	modern
rolechange	A man can be responsible for looking after the home and children just as well while the woman works full-time.	Fathers' role	modern
fulldadbad	A father who works full-time cannot care for his children properly.	Fathers' role	traditional

Notes: Answer categories are completely disagree, tend to disagree, tend to agree, and completely agree. Each statement is coded so that higher values indicate a more traditional view. Source: ALLBUS.

I follow this distinction between traditional and egalitarian/modern attitudes towards gender roles. Following Blohm & Walter (2018), traditional attitudes towards the gender division of work posit that women are primarily responsible for childcare and household tasks, while men are mainly supposed to do paid work. Egalitarian attitudes, on the other hand, support equal roles for men and women. According to this, agreement with the item 'rolechange' ("A man can be responsible for looking after the home and children just as well while the roman works full-time."), one of the newly introduced items, can be interpreted as modern. If respondents evaluate the consequences of female labour force participation as negative for child development, this is considered traditional. On the other hand, if the consequences of the labour force participation of mothers is not considered to hurt child development, this is coded as modern. The same logic applies to the interpretation of attitudes

towards the consequences of fathers' labour force participation (see Blohm & Walter 2018, Walter 2018*b*): agreement with the statement 'fulldadbond' ("A father working full-time can normally establish just as close a relationship with his small child as a father who doesn't work.") can be interpreted as modern, whereas agreement with the statement 'fulldadbad' ("A father who works full-time cannot care for his children properly.") is interpreted as traditional.

In addition to representing a traditional-modern spectrum, the ALLBUS items can be grouped according to different theoretically relevant dimensions (Blohm & Walter 2018). These are (i) attitudes towards the division of paid and unpaid work between men and women (hereafter called gender division of tasks); (ii) attitudes towards the consequences of female labour force participation for child development (hereafter called LFP of mothers); and (iii) attitudes towards the role of men in the family (hereafter called role of fathers). To simplify the analysis, rather than presenting results for all nine attitude items separately, I group them according to these three dimensions. Prior research on gender role attitudes uses additive indices on the different dimensions of gender role attitudes (e.g. Sjöberg 2004, Kotsadam & Finseraas 2011, Baxter et al. 2015). I therefore build three additive indices that form my outcome variables, each consisting of three items. These measures are shown in Figure 3.2.

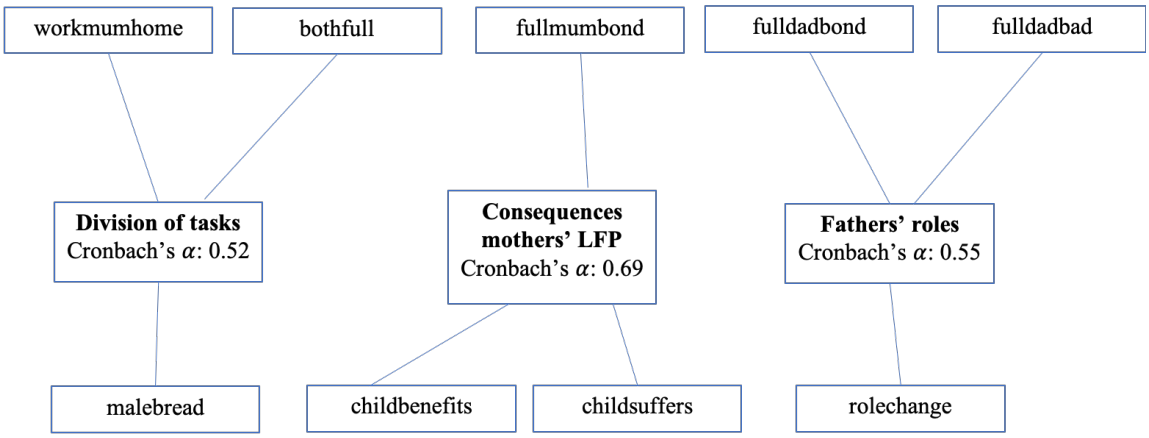

Figure 3.2: Indices of gender role attitudes

Source: Author's illustration based on ALLBUS.

To assess whether the items included in each index represent the same concept, I calculate Cronbach's alpha, a measure of internal consistency. While somewhat arbitrary, values between 0.6 and 0.8 are usually considered to be a good level of internal consistency (OECD 2008*b*). I report the values for Cronbach's alpha in Figure 3.2. The value for the LFP of mothers index is 0.69 but the values for the division of tasks and role of fathers indices are below 0.6. However, in both cases they are above 0.5 and thus close to the threshold. The relatively low values are partly due to the fact that each index consists of only three items. Overall, this suggests that the internal consistency of indices is acceptable but at the lower end. Considering the trade off between internal consistency and presenting each of nine items separately, I focus on the indices but also report the main results for each individual item.

Each item measures levels of agreement with four answer categories: 'completely disagree', 'tend to disagree', 'tend to agree', and 'completely agree'. I recode each item taking values between 0 and 3, with higher values indicating more traditional attitudes and lower values indicating more egalitarian or modern attitudes. Consequently, each of the three additive indices takes values between 0 and 9 as they are composed of three items each. I also construct an alternative measure for robustness checks, which is based on binary attitudes (in which 'tend to agree' and 'completely agree' are grouped together and 'tend to disagree' and 'completely disagree' are grouped together) . The indices then measure the number of statements the respondent has a traditional view on.

The key regressor is an indicator variable taking a value of zero if the relevant child was born between January 2005 and December 2006 (control group), and a value of one if the child was born between January 2007 and December 2008 (treatment group).

3.4.4 Summary statistics

Figure 3.3 shows the distribution of the three gender role attitude measures for the analysis sample. Each of the measures is an additive index of three items with higher values indicating higher levels of agreement with traditional gender roles. The measures on gender division of tasks and role of fathers are right-skewed and both have three as the modal value. In contrast, levels of agreement with traditional attitudes towards the LFP of mothers are higher, with a modal value of five.

Table 3.3 shows mean values of covariates for the full analysis sample, as well as for treatment and control groups. Covariates are balanced between the two groups with the following exceptions. By construction, child's age is higher in the control group than in the treatment group. Consequently, it is intuitive that respondents' age is also higher in the control group. Apart from these, none of the covariates are statistically different at the five percent level between the two groups, which strengthens the validity of the identification strategy. In particular, the number of children and age at first birth are balanced, suggesting that endogenous fertility is unlikely to be problematic. Moreover, the share of female respondents, share of tertiary educated, the probability to be employed or to be foreign born, and survey year are balanced. Most of the birth months are also balanced, with the exception of April and December, and the difference is statistically significant at the 10 percent level.

For the unbalanced variables, it is important to include them as controls in the analysis. Therefore, I include controls for respondents' age and square of age, child's age and square of age, and month of birth dummies in all specifications. A key assumption of the analysis is that there is no endogenous selection into treatment via fertility. Therefore, it is reassuring that treatment and control groups are balanced in terms of total number of children and in terms of key socioeconomic characteristics such as the share of tertiary-educated.

Figure 3.4 shows mean values of the outcome variables for the treatment and control groups. Average levels of agreement are highest for traditional attitudes

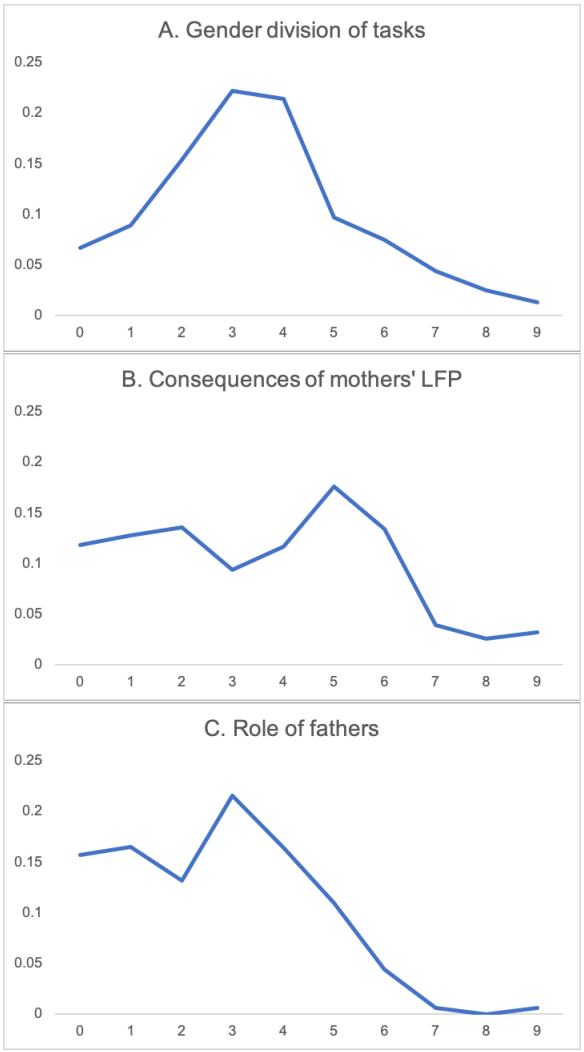

Figure 3.3: Distribution of outcome variables

Notes: The horizontal axes indicate values of the index and the vertical axes indicate the share of respondents. Each index takes values from zero to nine and higher values indicate more traditional attitudes. Source: ALLBUS.

concerning the LFP of mothers measure and lowest concerning the role of fathers. We can also see a statistically significant difference between treatment and control groups for one of the three outcomes: Traditional attitudes towards the role of fathers are higher in the treatment group compared to the control group. Mean values for traditional attitudes concerning the gender division of tasks are slightly higher in the treatment group, but the difference is not statistically significant. Mean values for attitudes towards the LFP of mothers are the same in both groups.

Table 3.3: Covariate balancing across treatment and control groups

	Control	Treatment	Total	Difference significant
Age	41	37.8	39	***
Number of children	2	2.1	2.1	
Age at first birth	29.1	29.1	29.1	
Female	0.58	0.59	0.59	
Tertiary degree	0.49	0.43	0.45	
Married	0.78	0.78	0.78	
Lives with partner	0.9	0.93	0.92	
Employed	0.85	0.78	0.8	
Foreign born	0.17	0.17	0.17	
Lives in East Germany	0.12	0.15	0.14	
Survey year 2012	0.47	0.48	0.48	
Survey year 2016	0.53	0.52	0.52	
Child's age (in months)	101.1	77.6	86.2	***
Child's birth month January	0.06	0.1	0.09	
Child's birth month February	0.1	0.06	0.07	
Child's birth month March	0.09	0.07	0.08	
Child's birth month April	0.02	0.08	0.06	*
Child's birth month May	0.04	0.09	0.08	
Child's birth month June	0.06	0.08	0.07	
Child's birth month July	0.05	0.07	0.07	
Child's birth month August	0.08	0.08	0.08	
Child's birth month September	0.12	0.12	0.12	
Child's birth month October	0.14	0.07	0.09	
Child's birth month November	0.06	0.1	0.08	
Child's birth month December	0.18	0.07	0.11	*
Number of observations	66	119	185	

Notes: Survey weights used. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

3.5 Results

3.5.1 Longer-term trends in gender role attitudes

In the main analysis, I compare the gender role attitudes of treatment and control groups, where attitudes of both groups are recorded in the same survey year. To put the analysis into the larger context, in this subsection I present longer-term trends in gender role attitudes in Germany. As mentioned in the previous section, most of the attitude items in the main analysis were introduced for the first time in 2012. For the longer-term trends, I am thus only able to construct measures for two dimensions, the gender division of tasks and consequences of mothers' labour force participation. These two measures consist of the old GRA items and not of those in the main analysis, and hence they are not directly comparable to each other. The

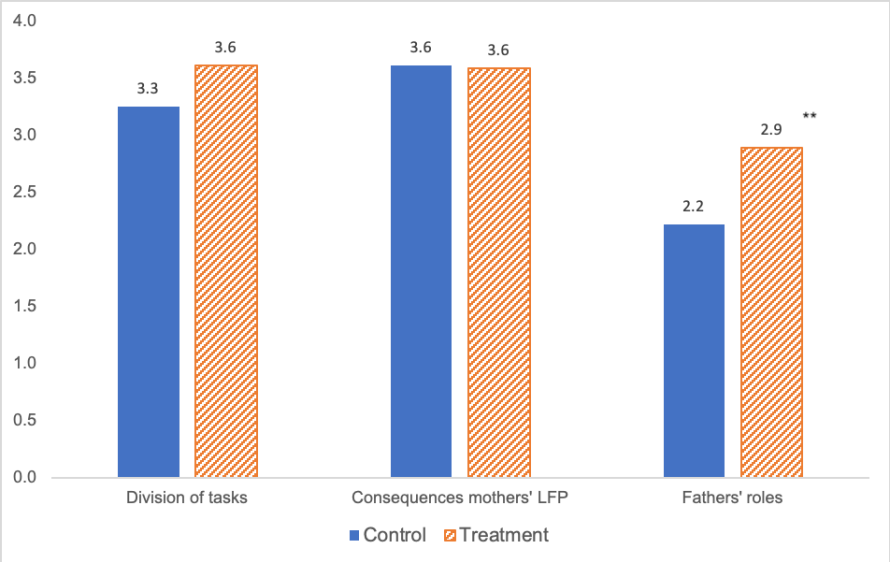

Figure 3.4: Mean of dependent variables for treatment and control groups

Notes: Survey weights used. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

items included in each measure are shown in Table 3.A.1 of Appendix 3.A. Each measure is an additive index taking values between zero and three. The measures consist of three items each and indicate the number of items that a respondent expressed agreement with a traditional view.

Figure 3.5 presents fitted values with 95 percent confidence intervals for the measures on attitudes towards the gender division of work (left-hand side) and the consequences of female labour force participation (right-hand side) by survey year. All regressions are estimated via OLS and include controls for sex, age, square of age, indicator variables for having tertiary education, being married, living with a partner, having at least one child, being employed, being foreign-born, living in East Germany, and dummy variables for survey years. The sample includes all respondents aged between 21 and 55, corresponding to the age range of the main analysis sample. The sample size is 7,457 respondents for the division of tasks measure (left-hand side) and 7,526 for the LFP of mothers measure (right-hand side). The top row in Figure 3.5 shows the trends for the full sample. For both measures, we observe a downward trend over the period from 2000 to 2016. In line

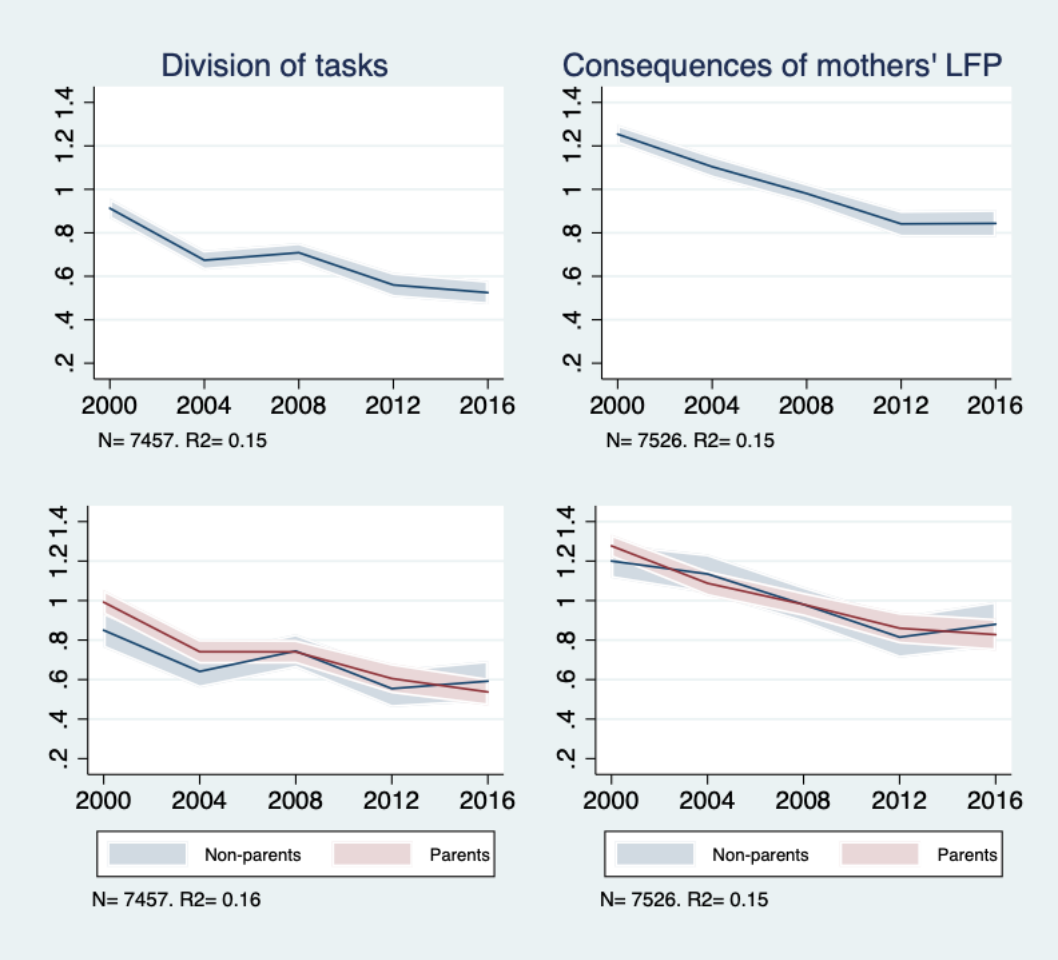

Figure 3.5: Trends in gender role attitudes I

Notes: Graphs show predicted values of GRA indices from linear regressions controlling for sex, age, square of age, indicator variables for having tertiary education, being married, living with a partner, having at least one child, being employed, being foreign-born, living in East Germany, and dummy variables for survey years. Graphs in bottom panel are from models fully interacted with binary variable indicating parental status. Indices take values from zero to three, with higher values indicating more traditional attitudes. Indices include the attitude items shown in Table 3.A.1. Survey weights used. Source: ALLBUS.

with the measures of the main analysis, attitudes on the consequences of LFP of mothers are on average more traditional than those on the gender division of tasks.

The bottom row of Figure 3.5 shows trends separately for parents and non-parents. These are obtained from regression models that are fully interacted by whether the respondent has children. The downward trends in traditional gender role attitudes are present for both groups and they are very similar among parents

and non-parents.

In Figure 3.6, I present trends in attitudes for groups distinguished by sex, educational level, and region of residence. Again, each of them is obtained from models fully interacted by the grouping variable. The figures reveal that (i) for all six groups, we observe a downward trend in traditional attitudes over the time period; (ii) for all six groups except residents in East Germany, attitudes towards the consequences of mothers' labour force participation are more traditional than those towards the gender division of tasks; (iii) men hold more traditional attitudes than women; (iv) those with lower levels of education hold more traditional attitudes than those with a tertiary degree; (v) West Germans hold more traditional attitudes than East Germans.

Taken together, the trends from this section reveal that attitudes towards the gender division of work and the consequences of female labour force participation have modernised since the start of this century – both overall and among all subgroups considered. Moreover, results corroborate findings from existing literature that attitudes differ by education, sex, and between East and West Germany (e.g. Blohm & Walter 2018). Interestingly, we do not see large differences in attitudes between parents and non-parents. It is not possible to attribute any of the observed trends in gender role attitudes to norm-setting policy feedback effects of the 2007 reform described in Section 3.3, though it is theoretically possible that such effects have contributed to the evolution of gender role attitudes.

3.5.2 Results on extended sample and for individual attitudes

Three of the attitude questions are included in both the 'old' and 'new' set of survey items. Hence, they were given to all respondents in the 2012 and 2016 survey waves and not just half. Moreover, they were included in the 2008 survey. Therefore, I estimate the effect of the reform on these three outcomes, namely 'childsuffers', 'malebread', and 'childbenefits' using a larger sample that includes all respondents

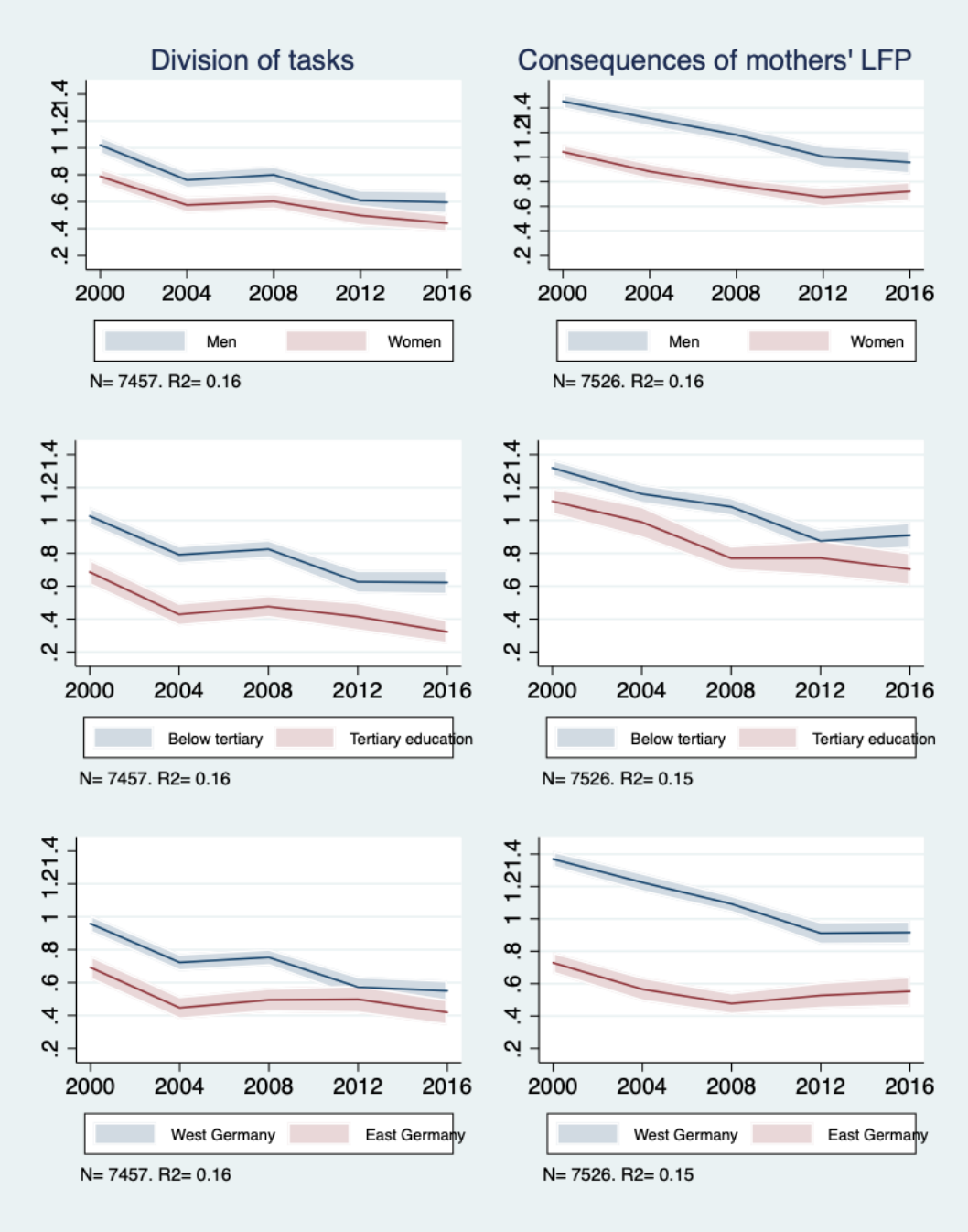

Figure 3.6: Trends in gender role attitudes II

Notes: Graphs show predicted values of GRA indices from linear regressions controlling for sex, age, square of age, indicator variables for having tertiary education, being married, living with a partner, having at least one child, being employed, being foreign-born, living in East Germany, and dummy variables for survey years. All models are fully interacted with the respective grouping variable. Indices take values from zero to three, with higher values indicating more traditional attitudes. Indices include the attitude items shown in Table 3.A.1. Survey weights used. Source: ALLBUS.

from the survey years 2008, 2012, and 2016. The full statement that each variable refers to is shown in Table 3.2.

Similarity between these results on a larger sample and those from the main analysis sample would increase confidence that the main analysis sample is not selective but representative. The results in Table 3.4 show that the reform did not affect agreement with any of these statements. Instead, the coefficients are all close to zero.

Table 3.4: Results on individual attitude items for extended sample

Dependent variable	childsuffers (1)	malebread (2)	childbenefits (3)
Treatment	0.027	0.029	-0.011
	(0.094)	(0.083)	(0.083)
Observations	591	593	586
R-squared	0.069	0.080	0.031
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values from 0 to 3, with higher levels indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Figure 3.7 then shows the mean values of these three attitude items for (i) the extended sample without observations that are also included in the main analysis and (ii) the main analysis sample. As before, each item can take values between zero and three, with higher values indicating more traditional attitudes. The figure shows that means are very similar between the two samples and not significantly different across the two groups for any of the items.

Table 3.5 then presents estimates of the effect of being eligible for the new benefit on each of the attitudinal variables for the main analysis sample as described in Section 3.4. Columns 1 to 3 present results on the three items that form the index gender division of tasks, columns 4 to 6 show items included in the measure consequences of mothers' labour force participation, and columns 7 to 9 show items included in the measure fathers' roles. The results show that the reform did not

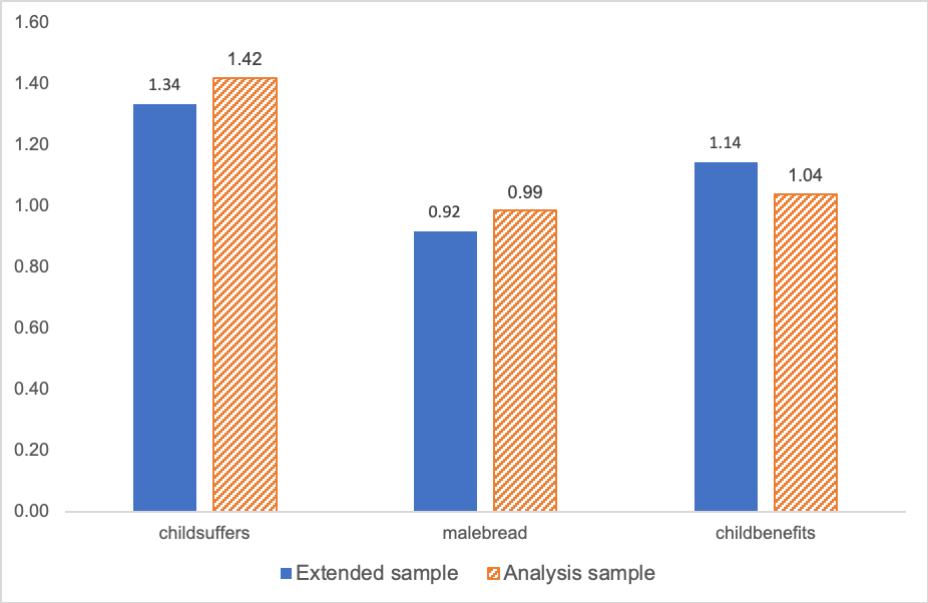

Figure 3.7: Difference in gender role attitudes between extended sample and analysis sample

Notes: Each dependent variable can take values from 0 to 3, with higher levels indicating more traditional attitudes. Extended sample includes year 2008 and the old split of 2012 and 2016. Survey weights used. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

affect any of the items included in the gender division of work and mothers' LFP measures. A comparison of these results with those from Table 3.4 on the extended sample increases confidence that the main analysis sample is not a selective sample despite its small number of observations. In particular, there is no statistically significant effect of the reform on the outcomes 'malebread' (column 2), 'childbenefits' (column 5), and 'childsuffers' (column 6).

Table 3.5: Results on individual attitude items

Dependent variable	bothfull (1)	malebread (2)	workmumhome (3)	fullmumbond (4)	childbenefits (5)	childsuffers (6)	fulldadbond (7)	rolechange (8)	fulldadbad (9)
Treatment	0.064	-0.028	0.176	0.049	0.115	-0.062	0.479***	0.252**	0.312*
	(0.168)	(0.154)	(0.169)	(0.207)	(0.151)	(0.207)	(0.163)	(0.112)	(0.176)
Observations	184	185	185	185	182	185	184	185	185
R-squared	0.163	0.139	0.191	0.133	0.098	0.109	0.113	0.133	0.057
Age controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Child age controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Birth month FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values from 0 to 3, with higher levels indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

The results also show that the reform has an effect on the items that relate to the role of fathers: The reform increased traditional views for all three items 'fulldadbad', 'fulldadbond', and 'rolechange'. That is, parents eligible for the new benefit exhibit higher levels of agreement with the statement that 'a father who works full-time cannot care for his children properly', lower levels of agreement with the statement 'a father working full-time can normally just establish as close a relationship with his small child as a father who doesn't work', and lower levels of agreement with the statement 'a man can be responsible for looking after the home and children just as well while the woman works full-time'.

In the next subsection, I present results for the three indices as described in Section 3.4 rather than each individual attitude question.

3.5.3 Main results

Table 3.6 presents the main results of the effect of the reform on gender role attitudes. Each column displays results for one of the three additive indices on gender roles: gender division of tasks (column 1), consequences of mothers' labour force participation (column 2), and fathers' roles (column 3). Each measure is coded so that higher values indicate more traditional views. I control for the characteristics that differ between the treatment and control group. These are respondent's age and square of age, child's age and square of age, and month of birth fixed effects.

Those affected by the reform report higher levels of agreement with a traditional gender division of tasks (column 1) and higher levels of agreement with traditional views on the consequences of female labour force participation (column 2), but these results are not statistically significant. I find one statistically significant effect of the reform: Those affected by the Elterngeld benefit report higher levels of agreement with traditional roles for fathers (column 3). The coefficient suggests that those with children born after the reform have 1.04 higher agreement with men's traditional gender roles, on a scale from 0 to 9. Compared to the mean score of the control group of 2.2, that is approximately a 47 percent increase. However, these estimates

Table 3.6: Main results: effect of new benefit on GRA indices

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.213	0.162	1.041***
	(0.358)	(0.441)	(0.336)
Observations	184	182	184
R-squared	0.117	0.131	0.092
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

should be interpreted with caution - due to the small sample size, the point estimate is not very precisely estimated with the 95 percent confidence interval ranging from 0.38 to 1.70. Moreover, the linear regression model does not account for the ordinal scale of the outcome variables. Therefore, I also present results from an ordered probit model in Table 3.A.2 in Appendix 3.A. The results stay substantively the same.

These findings are in line with both exposure effects as well as with norm-setting effects of the reform (see Section 3.3), though it is not possible to disentangle these two mechanisms based on the empirical analysis.

Apart from levels of agreement, it is also of interest whether respondents agree or disagree with a statement. Therefore, in Table 3.7, I present results for indices that are based on binary attitudinal variables. The indices show the number of items a respondent has a traditional view on. The sign of coefficients remains positive for all outcomes and the coefficient on male modern gender roles remains significant at the 5 percent level.

The inclusion of the control variables on respondents' age, child's age, and birth month is important as these variables differ across treatment and control groups. For completeness, results without controls and a stepwise introduction of controls are presented in Table 3.A.3 of Appendix 3.A. The table shows that results stay

Table 3.7: Main results for GRA indices based on binarised attitude items

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.127	0.105	0.353**
	(0.176)	(0.191)	(0.150)
Observations	184	182	184
R-squared	0.121	0.123	0.077
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 3, indicating the number of items the respondent had a traditional view on. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

very similar when excluding these control variables.[5]

3.5.4 Robustness checks

In this subsection, I perform various checks to study the robustness of the main results presented in Table 3.6. As mentioned in Section 3.4, the main threat to identification is potential bias arising from endogenous selection into treatment, which in this context is equivalent to endogenous fertility. Due to the quick and unanticipated introduction of the reform, parents within three months of the cutoff could not have known that the reform would be in place at the time they conceived (Kluve & Schmitz 2018). This reasoning also implies that it was not possible for parents to select into the control group for those who were worse off after the reform.

However, individuals who did not choose to become parents or to have an additional child given the pre-reform benefits may have done so under the new Elterngeld benefit policy. This is most likely the case for highly-educated people who on average benefited most from the reform. Indeed, previous research found that the Elterngeld reform increased fertility of high-educated groups (Raute 2019). Highly-educated people who would not have chosen to become parents or have an additional child under the old benefits regime became parents or had additional children un-

[5]Results for the West German subsample are shown in Appendix 3.A in Table 3.A.4, and heterogeneity across East and West Germany is discussed at the end of this section.

der the new regime, hold on average more gender-egalitarian attitudes. Therefore, this would likely introduce a downward bias to the effect that I find for attitudes towards the roles of fathers. Nevertheless, in what follows I perform various robustness checks to make sure that endogenous fertility is not driving the results.

In Table 3.8, I start by varying the window of children's birth dates included in treatment and control groups. If the results stay similar across different analysis windows, it increases confidence that endogenous selection into treatment is not driving the main findings. In Panel A of Table 3.8, I increase the window of births from 24 months to 36 months before and after the reform. The size of the coefficients for the attitude measures division of work (column 1) and LFP of mothers (column 2) become slightly larger compared to the main coefficients in Table 3.6 but remain insignificant despite smaller standard errors. The size of the coefficient on fathers' roles becomes marginally smaller and stays significant at the one percent level.

In Panel B of Table 3.8, I keep the window for the control group at 24 months, as in the baseline specification, but I shorten the window of the treatment group to six months. The rationale for varying only the treatment group window is that parents could select intro treatment group but not the control group. The coefficients for all three attitudinal outcome variables remain positive and their magnitude increases. Due to the smaller sample size, the standard errors also increase. Again, the coefficients for the outcomes gender division of work (column 1) and LFP of mothers (column 2) are not significant but the coefficient for the outcome gender roles of fathers (column 3) remains statistically significant at the five percent level.

In Panel C, I reduce the window of births from 24 months to 12 months before and after the reform. Again, the standard errors are substantially larger compared to the main results. The estimates for the outcome measures division of work (column 1) and mothers' LFP (column 2) become close to zero, while the estimate for the outcome fathers' roles (column 3) stays similar in size and statistically significant at the 10 percent level despite the larger standard error. These results increase our confidence that endogenous selection into treatment is not driving the findings.

Another concern is that parents with children born closely around the reform

Table 3.8: Sensitivity analysis: window of births for treatment and control groups

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Panel A. 36 months window			
Treatment (36m window)	0.312	0.305	0.929***
	(0.295)	(0.379)	(0.279)
Observations	287	284	285
R-squared	0.071	0.057	0.068
Panel B. 24 months for control, 6 months for treatment			
Treatment (24/6m window)	0.530	0.753	1.507**
	(0.573)	(0.805)	(0.664)
Observations	88	86	88
R-squared	0.295	0.143	0.230
Panel C. 12 months window			
Treatment (12m window)	-0.016	-0.075	0.997*
	(0.479)	(0.636)	(0.501)
Observations	91	90	92
R-squared	0.292	0.238	0.257
Panel D. Excluding births within a month of reform			
Treatment	0.301	0.211	1.261***
	(0.369)	(0.458)	(0.345)
Observations	171	170	171
R-squared	0.122	0.129	0.105
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

cutoff date may have manipulated their eligibility by delaying birth, as suggested by findings in Neugart & Ohlsson (2012). Panel D of Table 3.8 therefore excludes those with children born within a month of the cutoff, that is, those with children born in December 2006 or January 2007. The sign of all coefficients remains the same and their size comparable in magnitude to the main results of Table 3.6.

Taken together, in Table 3.8 I have presented results for four different analysis windows. Independently of how I define the windows, the reform had no significant effect on attitudes towards the gender division of work or the LFP of mothers measures. Moreover, the sign of coefficients remains positive or close to zero. Additionally, in all specifications, I observe a positive and statistically significant effect of treatment on traditional gender roles for fathers. This increases confidence that the results are not driven by endogenous fertility.

Next, I study more directly whether those affected by the reform are more likely to have further children. I analyse whether treatment predicts the number of children and results are presented in Table 3.9. Column 1 shows that the main treatment variable does not predict the total number of own children living in the household. In columns 2 to 4, the outcomes are binary variables for having one, two, or three and more children, respectively. Results reveal that treatment does not predict the probability to have any specific number of children. Taken together, the results from Table 3.9 strengthen the view that endogenous fertility choices do not play an important role.

As described in Section 3.4, for those who had more than one child between 2005 and 2008, I consider the lastborn child for the classification into treatment and control groups. The rationale for this choice is that anybody who was affected by the reform is considered to be treated, independent of the birth order of the child. Those in the treatment group may or may not have additional children after 2008.

It could be argued that considering only the lastborn child would make treatment and control groups more similar, but the downside is that results may be more sensitive to endogenous fertility. In Panel A of Table 3.10, I study the reform effects when treatment and control groups are constructed based on the lastborn child

Table 3.9: Robustness check: effects on fertility

Dependent variable	Number of children (1)	One child (2)	Two children (3)	Three or more children (4)
Treatment	0.130	-0.046	-0.011	0.057
	(0.158)	(0.086)	(0.089)	(0.084)
Observations	185	185	185	185
R-squared	0.072	0.111	0.159	0.098
Age controls	yes	yes	yes	yes
Child age controls	yes	yes	yes	yes
Birth month FEs	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

only. The results on all outcomes are very similar to those of the main analysis. This similarity in findings further reduces concerns that endogenous fertility may be driving the results. It also suggests that the effect of treatment does not depend on the parity of the child.

In Panel B of Table 3.10, I also study results when treatment and control groups are based on the firstborn child only. This effectively creates three differences compared to the classification in the main results. First, those who had more than one child between 2005 and 2008 are now classified as control group instead of treatment group despite having experienced the new benefit. Second, parents who had their first child in 2005 or 2006 and another child post-2008 were not considered in the main analysis but now form part of the control group. Third, anyone who had their first child prior to 2005 will not be included in the sample of this robustness check, despite having further children born between 2005 and 2009. The coefficients for division of tasks and for mothers' LFP remain insignificant and small in size. In addition, the coefficient on fathers' roles (column 3) is almost halved compared to the main results, and becomes insignificant. The insignificant results for the outcomes division of tasks and mothers' LFP, and the positive but smaller coefficient for the outcome fathers' roles further strengthen confidence in the main results.

Moreover, these results are likely downward biased because those in the control group may actually have had a second child during the treatment period, and thus

Table 3.10: Sensitivity analysis first child and last child

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Panel A. Lastborn child			
Treatment (based on last child)	0.357	0.154	0.938**
	(0.386)	(0.480)	(0.363)
Observations	147	144	146
R-squared	0.155	0.175	0.092
Panel B. Firstborn child			
Treatment (based on first child)	-0.131	0.116	0.515
	(0.405)	(0.486)	(0.363)
Observations	121	120	121
R-squared	0.134	0.137	0.117
Panel C. Subsample those with one child only			
Treatment	-0.007	-0.040	0.512
	(0.742)	(0.989)	(0.766)
Observations	53	51	52
R-squared	0.293	0.404	0.230
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

have experienced the new benefit. Therefore, these results suggest that gender role attitudes do not remain stable after the transition to parenthood but instead that experiences can alter attitudes independent of child parity.

In Panel C of Table 3.10, I study results for the subsample of parents who have only one child at the time of interview. This sample is very small and hence standard errors more than double compared to the main results in Table 3.6. Nevertheless, the coefficients for the first two outcome variables are very close to zero, while the coefficient for fathers' roles remains positive and sizeable at 0.51. The fact that the results stay similar when considering only one-child respondents give further reassurance that results are not driven by endogenous fertility choices.

Next, I study whether the introduction of additional control variables alters

results. In the main specification in Table 3.6, I control only for the covariates that are not balanced across treatment and control groups. Panel A of Table 3.11 shows results from a regression with additional control variables which have been shown to affect gender role attitudes. These are a binary variable indicating tertiary education and a binary variable indicating whether respondents are foreign born. The estimates do not change by much when adding these controls.

Table 3.11: Robustness check: additional control variables

Dependent variable	Gender division	LFP of mothers	Roles of fathers
	(1)	(2)	(3)
Panel A. Additional control variables education and migration			
Treatment	0.234	0.188	1.065***
	(0.360)	(0.437)	(0.337)
Observations	184	182	184
R-squared	0.150	0.168	0.105
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes
Additional controls	education & migration	education & migration	education & migration
Panel B. Year controls			
Treatment	0.288	-0.017	0.743**
	(0.358)	(0.392)	(0.321)
Observations	184	182	184
R-squared	0.116	0.133	0.099
Age controls	yes	yes	yes
Child age controls	no	no	no
Birth month FEs	yes	yes	yes
Additional controls	survey year	survey year	survey year

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables in Panel A include age (in years), age squared, a binary variable indicating tertiary education, a binary variable indicating foreign birth country, child's age (in months), child's age squared, and month of birth dummies. Control variables in Panel B include age (in years), age squared, survey year, month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

The sample consists of respondents interviewed in 2012 and 2016, hence the results capture the effects of the reform on reported attitudes 5 and 9 years after its introduction. The rationale behind pooling the years is to maximise sample size. Importantly, the interview year is balanced as shown in Table 3. In Panel B of Table

3.11 , I report results when adding a dummy variable indicating interview year 2016 as a control, and results are robust to this. I exclude the age of child controls, as age of the child and interview year are very highly correlated by construction. Again, the results remain qualitatively similar compared to the main results.

To further strengthen confidence in the paper's estimation strategy, I estimate the effects of hypothetical 'placebo' reforms constructed to be introduced on a different date than the actual parental leave reform. I estimate the effects of a placebo reform being introduced at the start of each month, for each date between January 2004 and December 2011. Treatment and control groups are constructed in the same way as in the main analysis, using a 24 month window around the date of the reform. Figure 3.8 presents coefficients and 95 percent confidence intervals across different hypothetical introduction dates. No significant results for placebo reforms taking place on January 2005 or before, or on January 2009 or after would strengthen confidence that the results obtained earlier can indeed be attributed to the parental leave reform. This is because treatment and control groups for placebo reforms on January 2005 or before were both exposed to the same benefit Erziehungsgeld. Similarly, treatment and control groups for placebo reforms on January 2009 or after were both exposed to the new benefit Elterngeld. For placebo reforms taking place between February 2005 and December 2008, there is some overlap in treatment and control groups with those of the actual reform, and that overlap becomes larger the closer the placebo date is to January 2007. For the significant results on attitudes towards the role of fathers obtained earlier, we would therefore expect a phasing out of these results the further the placebo reforms are away from January 2007.

Indeed, the graphs for the outcomes gender division and LFP of mothers show that coefficients remain statistically insignificant throughout (apart from two exceptions for the outcome gender division which show up as marginally significant). Moreover, the graph on the outcome role of fathers confirms a clear statistically significant effect around January 2007 as well as 'phasing-out' effects, as expected. Again, there are generally no statistically significant effects outside the period between January 2005 and January 2009, with a few exceptions of marginally signifi-

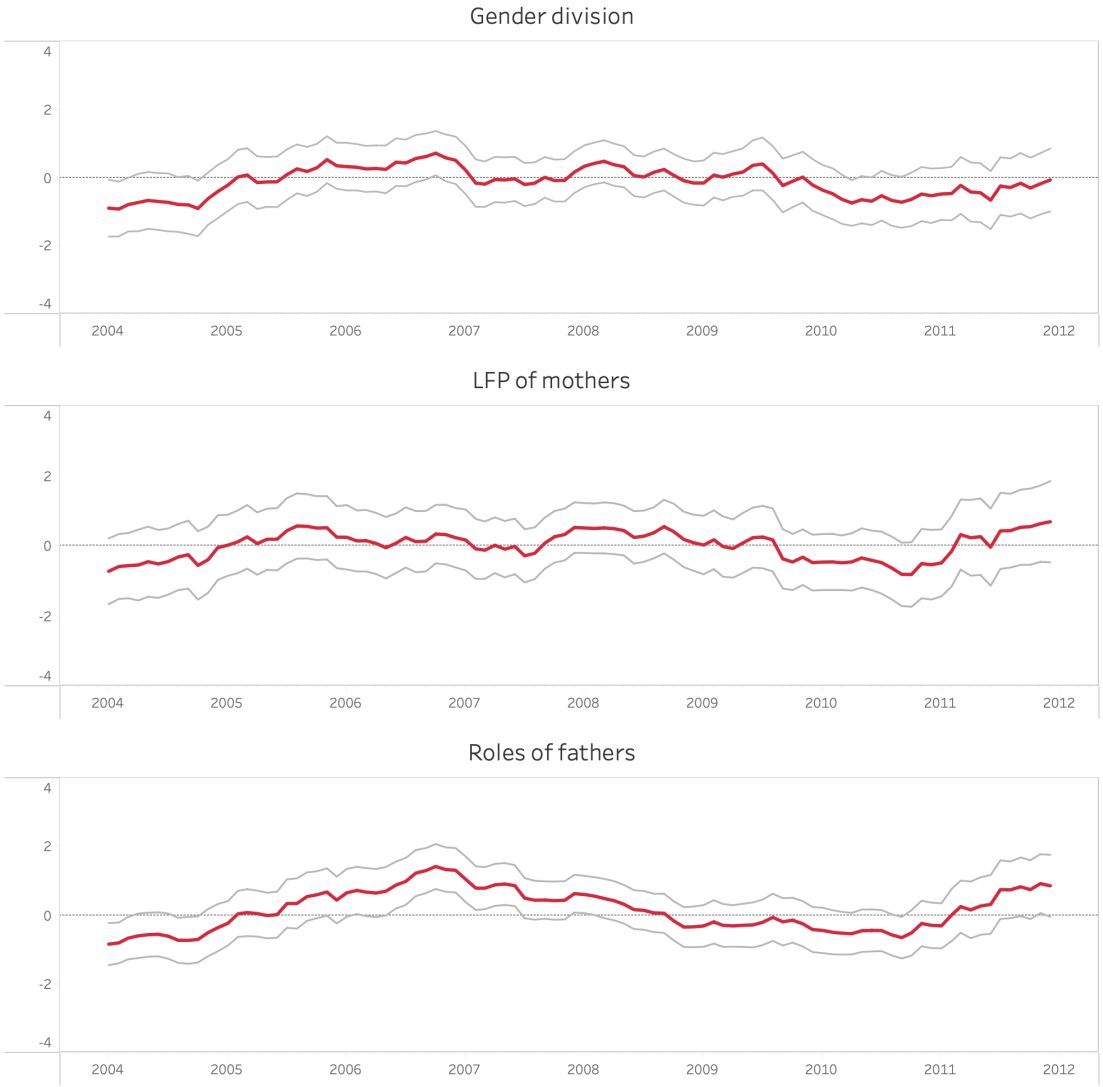

Figure 3.8: Placebo reforms

Notes: Figures show coefficients and 95 percent confidence intervals from separate regressions of placebo reforms constructed to be introduced at the start of each month for the period between 2004 and 2011. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Robust standard errors used. Source: ALLBUS.

cant coefficients outside of this period. Overall, results from these placebo reforms further strengthen the confidence in this paper's estimation strategy. They show that results are not driven by time trends and they further reduce concerns about omitted variable bias due to unobserved differences between treatment and control

groups.

To sum up, I have argued in this section that any potential bias arising from endogenous fertility may likely introduce a downward bias to the estimated results. Nevertheless, I provided a variety of robustness checks addressing concerns of endogenous fertility and omitted variable bias and results are robust to these additional checks.

3.5.5 Heterogeneity and other outcomes

I have shown that the parental leave reform increased traditional attitudes towards the role of fathers and did not affect attitudes towards the gender division of work or the consequences of mothers' labour force participation for child development. These results are robust to a variety of robustness checks. In this subsection, I study the heterogeneity of results across the different groups considered in the trends analysis in Figure 3.6. These are sex, educational level, and region. As discussed in Section 3.3, based on theories of exposure, we would expect fathers to be more likely to change their attitudes in response to the policy change compared to mothers, and we would expect highly-educated fathers to be more likely to change attitudes compared to fathers with lower levels of education.

I start with heterogeneity analyses by respondent sex, presented in Table 3.12. I interact the main treatment effect with a dummy for women, and I also show the linear combination of treatment and being a woman at the bottom of the table. Columns 1 and 2 reveal that the coefficient on the effect of the reform for men is positive, while the interaction between the treatment and the woman dummy is negative. The overall effect of the reform for women is also negative, as indicated by the linear combination of estimates. However, none of the coefficients is statistically significant. For attitudes towards the role of fathers in column 3, the main coefficient on the treatment variable is positive and statistically significant, indicating that the reform increased men's levels of agreement with traditional roles for fathers. Moreover, the interaction effect between treatment and the woman dummy for the

Table 3.12: Heterogeneity by sex

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.588	0.719	1.687***
	(0.471)	(0.650)	(0.488)
Woman	0.157	-0.223	0.670
	(0.492)	(0.673)	(0.470)
Treatment x woman	-0.727	-1.172	-1.159*
	(0.603)	(0.783)	(0.591)
Observations	184	182	184
R-squared	0.128	0.172	0.113
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes
Treatment + woman	-0.139	-0.454	0.528
	(0.457)	(0.510)	(0.407)

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

outcome attitudes towards men's roles is negative and statistically significant. The overall effect of the reform on attitudes towards men's roles for women is much smaller and not statistically significant. This shows that, as expected, the main results on the outcome attitudes towards fathers' roles is driven by a change in men's attitudes.[6]

Next, I study heterogeneity of results by level of education. The results are presented in Table 3.13 and show that the effects of the reform are not significantly different between those with tertiary education and those with lower levels of education. However, the coefficient for attitudes towards the role of fathers is larger for those with tertiary education, as expected.

Table 3.14 studies how results differ across East and West German residents. The negative and statistically significant coefficients on the East dummy indicate that East Germans hold less traditional attitudes towards the gender division of

[6]Given that the results for the outcome 'roles of fathers' are significantly different for men and women, I provide additional results on the heterogeneity by sex for the subsample of West Germans as well as for each individual attitudinal item in Appendix 3.A, Tables 3.A.5 and 3.A.6.

Table 3.13: Heterogeneity by education

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.320	0.030	0.757*
	(0.502)	(0.598)	(0.448)
Tertiary degree	-0.533	-1.017	-0.406
	(0.512)	(0.636)	(0.473)
Treatment x tertiary degree	-0.209	0.248	0.551
	(0.682)	(0.832)	(0.629)
Observations	184	182	184
R-squared	0.139	0.159	0.097
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes
Treatment + tertiary degree	0.110	0.278	1.309***
	(0.490)	(0.618)	(0.476)

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Table 3.14: Heterogeneity across West and East Germany

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.219	0.183	1.117***
	(0.395)	(0.487)	(0.367)
East Germany	-1.233**	-1.488**	-0.337
	(0.520)	(0.653)	(0.599)
Treatment x East Germany	-0.061	-0.223	-0.532
	(0.706)	(0.807)	(0.732)
Observations	184	182	184
R-squared	0.163	0.184	0.110
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes
Treatment + East Germany	0.158	-0.0395	0.584
	(0.596)	(0.645)	(0.654)

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

work and the consequences of mothers' labour force participation. This is in line with results from Figure 3.6 as well as well-known findings from existing literature (e.g. Bauernschuster & Rainer 2012, Blohm & Walter 2018). On the other hand, attitudes towards the role of fathers (column 3) are not significantly different among East Germans. The interaction effects between treatment and the East dummy are negative but not significant in all three columns, suggesting that the treatment effect does not differ between East and West Germans. Nevertheless, the linear combination of estimates in column 3 reveals that the effect of the reform on attitudes towards the role of men is smaller and not statistically significant for East Germans. This suggests that the increase in traditional attitudes towards fathers' roles is predominantly driven by those residing in West Germany.

Taken together, results from this paper suggest that the Elterngeld benefit did not modernise attitudes towards the gender division of work and attitudes towards the consequences of female labour force participation. Moreover, it made parents' attitudes towards the role of fathers more traditional.

Table 3.15: Division of household (HH) and childcare (CC) tasks

Dependent variable	No. of HH tasks done mainly by woman	No. of HH tasks shared equally	No. of CC tasks done mainly by woman	No. of CC tasks shared equally
	(1)	(2)	(3)	(4)
Treatment	-0.600	0.244	0.045	-0.305
	(0.569)	(0.550)	(0.500)	(0.513)
Observations	85	85	81	81
R-squared	0.235	0.182	0.134	0.195
Age controls	yes	yes	yes	yes
Child age controls	yes	yes	yes	yes
Birth month FEs	yes	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

To strengthen interpretation of the obtained results, I study whether the reform affected the actual sharing of childcare and housework tasks and results are presented in Table 3.15. Given that the reform did not affect attitudes towards the gender division of tasks we would expect null effect on these outcomes as well. One caveat is

that these outcomes were only asked in 2016 and hence the sample size is very small and results should thus be interpreted with caution. The survey contains several household and childcare tasks such as cooking and asks respondents who performs each of these tasks. There are five answer categories, always the woman, mostly the woman, half each or together, mostly the man, and always the man. I create four indices as my outcome variables, each taking values from zero to three. The first counts the number of household tasks done mostly or always by the woman. It comprises three household tasks that are predominantly performed by women, cooking, doing laundry, and cleaning (column 1). The second comprises the same household tasks but counts the number of them that are equally shared (column 2). The third index counts the number of childcare tasks done mostly or always by the woman, comprised of playing with the kids, doing homework with the kids, and bringing the kids to bed (column 3). The final index counts the number of these childcare tasks that are performed equally or together (column 4). Results show that the reform did not affect the division of household and childcare tasks among couples. This strengthens the conclusion that the parental leave reform did not trigger a change towards more egalitarian views among those affected.

3.6 Discussion and conclusion

Parenthood often marks the starting point of persistent gender inequalities in paid and unpaid work. Against this background, I studied the impact of the 2007 parental leave reform in Germany on the gender role attitudes that affected parents held several years later. This reform constituted a turn in the direction of German family policy, away from support for a male breadwinner model in which the husband works and the wife stays at home, and towards incentives for mothers' employment and fathers' involvement in childcare.

The new benefit led to the emergence of a new social norm in which fathers take two months of parental leave and mothers return to the labour force relatively quickly given the German context, after 12 months (Unterhofer et al. 2017, Cygan-Rehm

et al. 2018). Nevertheless, evidence on fathers' involvement in and the division of childcare and housework tasks within couples is mixed (Kluve & Tamm 2013, Tamm 2019). Traditional attitudes towards gender roles may explain these mixed results. This paper contributes to the literature on the effects of the German parental leave reform, by studying its effects on attitudinal change.

I find that the reform failed to modernise gender role attitudes of those directly affected by the new benefit, compared to those who were parents before its introduction. Specifically, I find no effect on attitudes towards the gender division of work or on attitudes towards the consequences of mothers' labour force participation. Additionally, the reform increased support for traditional gender roles for fathers among parents affected by the reform, compared to parents before the reform. The new benefit did not impact the sharing of household and childcare activities within the family. I further find that the effect of the reform on increased support for traditional gender roles for fathers is driven by attitudinal changes of men. Results are also stronger for tertiary-educated parents and those living in West Germany. These findings are in line with both exposure and identity theories on the one hand, and with norm-setting policy feedback effects on the other hand.

Specifically, being offered the new benefit may have made fathers aware of work-care conflicts, both through their own experience from leave-taking as well as through the normative messages that the new policy carried and that they mentally engaged with when deciding whether and how much leave to take. Moreover, one could argue that the observed changes in attitudes closely match the incentives that the reform provided. The reform incentivised fathers to take leave and get more involved in childcare. In line with this, the reform increased support for traditional roles for men. Specifically, it increased agreement with the statement that fathers working full-time cannot care for their children properly. Similarly, it decreased agreement with the statement that a father working full-time can normally establish just as close a relationship with his small child as a father who doesn't work. Moreover, it decreased agreement with the statement that a man can be responsible for looking after the home and children just as well while the woman works full-time. These

results are in line with identity theories, suggesting that the new experience of leave-taking among fathers changed their parenting identities. At the same time, it may have altered their perceptions of career costs associated with taking leave. Results from heterogeneity analyses indicating that effects are stronger for tertiary-educated lend additional support for an exposure and identity interpretation, as the increase in parental leave usage was greatest among highly educated fathers (Geisler & Kreyenfeld 2019).

On the other hand, one could argue that the reform did not lead women to have new experiences to the same extent, as they were already taking leave before the reform. The null effect on attitudes towards the consequences of female labour force participation, and the finding that women did not change their attitudes towards the role of fathers, are in line with such an identity explanation. Moreover, while the reform incentivised fathers' leave-taking and mothers' return to work, it did not incentivise a gender-egalitarian division of roles. Instead, women still take most of the paid leave and return to work part-time more often. It may therefore not be surprising that the reform did not impact attitudes towards the gender division of work.

An analysis of time trends showed that attitudes towards the gender division of work and towards the consequences of female labour force participation held by German society at large have gradually become less traditional since the start of the 21st century. These results are in line with norm-setting policy feedback effects, however, it is not possible to attribute the observed changes in attitudes to such norm-setting effects of the policy reform. Specifically, it may be that the normative messages surrounding the reform contributed to a continued modernisation of gender role attitudes in society over time, both for those directly experiencing the new benefit as well as for wider society. Similarly, social interactions with those eligible for the new benefit may have led to changes in the attitudes of the control group and of wider society. In contrast, the actual eligibility for the benefit may not have changed attitudes towards the gender division of work and towards the consequences of mothers' labour force participation above and beyond overall

societal trends. Prior research showing that the reform modernised gender role attitudes in the grandparents' generation (Unterhofer & Wrohlich 2017) and that mothers' leave-taking decisions depended on those of their coworkers (Welteke & Wrohlich 2019) lend support to such an interpretation. Administrative statistics showing that the share of fathers who took parental leave has been gradually rising each year since 2007 also support the possibility of a more gradual modernisation of attitudes (Statistisches Bundesamt 2020). Therefore, the results do not rule out the possibility that the policy modernised societal attitudes gradually over time. It is possible that the general normative messages surrounding the reform rather than the direct treatment may be relevant for attitudinal change, particularly if treatment does not expose individuals to starkly new experiences.

In light of these interpretations, interesting avenues for future research would be to study whether the introduction of Elterngeld Plus in 2015, which facilitated a more gender equal division of work via additional leave granted to couples in which both work part-time, affected gender role attitudes. Additionally, further research on the effects of policy changes on attitudes that considers peer and network effects is needed.

This paper makes several contributions to existing literature. First, the paper improves our understanding of the possible policy feedback effects of parental leave policies on parents' gender role attitudes by providing the first analysis of the effects of the 2007 parental leave reform on attitudes. The only other study that has analysed the impact of a parental leave reform on parents' gender role attitudes is one from Norway. In line with the results from this paper, the study found that the introduction of a daddy quota did not affect parents' gender role attitudes towards the gender division of tasks and the consequences of female labour force participation (Kotsadam & Finseraas 2011). Significant changes in men's attitudes towards the role of fathers, however, provide evidence for the existence of policy feedback effects.

Second, the paper adds to the empirical literature on the effects of the Elterngeld. Overall, results from this literature indicate that the reform was effective in achieving the aims of a quicker labour market return of mothers and an increased

adoption of leave-taking among fathers. However, longer-term economic impacts, particularly with regards to gender equality in paid and unpaid work, are more controversial. Results from this paper provide evidence for the failure of the reform to modernise parental attitudes as a potential mechanism for these limited longer-term behavioural changes.

Third, results inform the broader literature on whether individual attitudes change over the life course. The robust effect of the reform on increased support for traditional attitudes towards the role of fathers suggests that policy can indeed affect attitudes but that impressionability may not always run in the intended direction. Moreover, new experiences must be different enough from previous ones in order to trigger attitudinal changes.

Apart from providing theoretically relevant insights concerning attitudinal change, the findings from this paper carry important policy implications. Specifically, the results from this paper suggest that policy can be an effective means to trigger attitudinal changes. Moreover, in order to increase support for a gender equal division of paid and unpaid work within families, policy needs to go further and actively incentivise such a division.

3.A Appendix tables

Table 3.A.1: Gender role attitude items included in 'old' indices

Item name	Item text	Index	Agreement considered as
suphusb	It's more important for a wife to help her husband with his career than to pursue her own career.	Division of tasks	traditional
malebread	It is much better for everyone concerned if the man goes out to work and the woman stays at home and looks after the house and children.	Division of tasks	traditional
wifenowork	A married woman should not work if there are not enough jobs to go around and her husband is also in a position to support the family.	Division of tasks	traditional
mumbond	A working mother can establish just as loving and secure a relationship with her children as a mother who doesn't work.	Mothers' LFP	non-traditional
childsuffers	A small child is bound to suffer if his or her mother goes out to work.	Mothers' LFP	traditional
childbenefits	A child actually benefits from his or her mother having a job rather than just concentrating on the home.	Mothers' LFP	non-traditional

Source: ALLBUS.

Table 3.A.2: Main results, ordered probit model

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.121	0.116	0.620***
	(0.183)	(0.191)	(0.187)
Observations	184	182	184
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from ordered probit models. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Table 3.A.3: Stepwise introduction of control variables

Dependent variable	Gender division			LFP of mothers			Roles of fathers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment	0.362	0.248	0.280	-0.026	0.018	0.020	0.676**	0.725**	0.817**
	(0.314)	(0.318)	(0.348)	(0.384)	(0.378)	(0.389)	(0.285)	(0.296)	(0.320)
Observations	184	184	184	182	182	182	184	184	184
R-squared	0.008	0.025	0.115	0.000	0.001	0.128	0.031	0.039	0.070
Age controls	no	yes	yes	no	yes	yes	no	yes	yes
Child age controls	no	no	no	no	no	no	no	no	no
Birth month FEs	no	no	yes	no	no	yes	no	no	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Table 3.A.4: Main results, West German subsample

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.240	0.207	1.175***
	(0.413)	(0.512)	(0.382)
Observations	136	134	136
R-squared	0.139	0.139	0.116
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Table 3.A.5: Heterogeneity by sex for each attitude item

Dependent variable	bothfull	malebread	workmumhome	fullmumbond	childbenefits	childsuffers	fulldadbond	rolechange	fulldadbad
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment	0.254	0.110	0.224	0.282	0.344	0.023	0.593**	0.506***	0.585**
	(0.211)	(0.214)	(0.232)	(0.294)	(0.247)	(0.288)	(0.249)	(0.150)	(0.267)
Female	0.173	-0.034	0.018	0.263	0.005	-0.505*	0.063	0.419***	0.183
	(0.245)	(0.239)	(0.234)	(0.300)	(0.266)	(0.293)	(0.233)	(0.146)	(0.283)
Treatment x female	-0.346	-0.287	-0.094	-0.413	-0.461	-0.289	-0.216	-0.421**	-0.513
	(0.285)	(0.286)	(0.300)	(0.355)	(0.313)	(0.340)	(0.298)	(0.195)	(0.336)
Observations	184	185	185	185	182	185	184	185	185
R-squared	0.170	0.153	0.191	0.140	0.130	0.184	0.117	0.165	0.075
Age controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Child age controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Birth month FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes
Treatment + female	-0.092	-0.178	0.131	-0.131	-0.117	-0.266	0.377*	0.086	0.072
	(0.222)	(0.204)	(0.219)	(0.250)	(0.182)	(0.230)	(0.197)	(0.145)	(0.219)

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 3, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Table 3.A.6: Heterogeneity by sex for West German subsample

Dependent variable	Gender division (1)	LFP of mothers (2)	Roles of fathers (3)
Treatment	0.687	0.739	1.911***
	(0.530)	(0.746)	(0.565)
Female	0.299	-0.309	0.783
	(0.536)	(0.748)	(0.516)
Treatment x female	-0.870	-1.230	-1.341**
	(0.665)	(0.879)	(0.663)
Observations	136	134	136
R-squared	0.152	0.191	0.145
Age controls	yes	yes	yes
Child age controls	yes	yes	yes
Birth month FEs	yes	yes	yes
Treatment + female	-0.183	-0.491	0.570
	(0.527)	(0.587)	(0.455)

Notes: Table shows estimates from OLS regressions. Each dependent variable takes values between 0 and 9, with higher values indicating more traditional attitudes. Control variables include age (in years), age squared, child's age (in months), child's age squared, and month of birth dummies. Survey weights used. Robust standard errors in parentheses. Levels of significance *** p<0.01, ** p<0.05, * p<0.1. Source: ALLBUS.

Chapter 4

Daughters and attitudes towards gender roles[1]

Abstract

We study the effect of parenting daughters on attitudes towards gender norms in the UK; specifically, attitudes towards the traditional male breadwinner norm in which it is the husband's role to work and the wife's to stay at home. We find robust evidence that parenting daughters decreases fathers' likelihood to hold traditional attitudes. This result is driven by fathers of school-aged daughters, for whom the effects are robust to the inclusion of individual fixed effects. Our estimates suggest that fathers' probability to support traditional gender norms declines by approximately 3 percentage points (8 percent) when parenting primary school-aged daughters and by 4 percentage points (11 percent) when parenting secondary school-aged daughters. The effect on mothers' attitudes is generally not statistically significant. These findings are consistent with exposure and identity theories. We conclude that gender norm attitudes are not stable throughout the life-course and can significantly be shaped by adulthood experiences.

[1]This chapter is written jointly with Mireia Borrell-Porta and Joan Costa-Font, and a version of it is published as: The 'mighty girl' effect: does parenting daughters alter attitudes towards gender norms? in Oxford Economic Papers, 71(1), 2019, pp. 25–46. An earlier working paper version is published in IZA Discussion Papers, No. 11259, Institute of Labor Economics (IZA), January 2018.

4.1 Introduction

In recent decades, concerns about gender equality have been increasingly prominent in both the political and the social spheres, prompting governments to embark on the task of alleviating gender differences inside and outside the labour market. Nevertheless, progress towards achieving gender equality appears to have gradually slowed down (Eagly & Wood 2012). Against this background, a growing body of research has established the importance of traditional gender norms in explaining the persistence of gender inequalities in wages (Burda et al. 2007), in labour force participation (Fernández et al. 2004, Fortin 2005, Fernández & Fogli 2009, Farré & Vella 2013, Johnston et al. 2014), and in the division of domestic work (DeMaris & Longmore 1996, Greenstein 1996, Davis & Greenstein 2009). However, there is limited evidence on how susceptible to change such norms are. This paper addresses this question.

Changing individual attitudes towards societal gender norms may be critical for further progress towards a less gendered division of work and towards gender equality more generally, since it may legitimize a wider range of social roles for both men and women (Eagly & Wood 2012). So far, the literature has focused mostly on long-term changes in norms across cohorts (Baxter et al. 2015), although research on individual changes in attitudes towards gender norms across the life cycle is gradually increasing. This latter approach has studied the role played by the family environment, including that of marriage, parenthood, and women's labour patterns inside and outside the household (see Clarkberg 2002, Corrigall & Konrad 2007, Cunningham 2008, Schober & Scott 2012, Baxter et al. 2015).

Our paper contributes to this literature by analysing one life course event that has received limited attention so far, namely the effect of parenting daughters. Using a British nationally representative longitudinal survey spanning two decades, we examine whether rearing daughters changes parental attitudes towards gender norms, and more specifically, attitudes towards the traditional male breadwinner norm in which it is the husband's role to work and the wife's role to stay at home.

Given that a child's sex cannot be anticipated, we assume that rearing a daughter - as opposed to a son - is an approximately random event (Washington 2008).[2]

In examining the individual change in attitudes towards gender norms, we borrow the definition of gender norms from Pearse & Connell (2016), who define them as 'collective definitions of socially approved conduct in relation to groups constituted in the gender order - mainly distinctions between men and women'. Hence, norms are defined as 'features of a collective life' (p.34) that signal to other members of a group or society how they should behave' (Schwartz 2012, p. 16), and closely follows definitions in other social science disciplines.

We find evidence that parenting daughters decreases fathers' likelihood to agree with a traditional male breadwinner norm. This is especially the case for fathers of school-aged daughters, for whom the effects are robust to a number of alternative specifications, and in particular the inclusion of individual fixed effects (FE) that control for time-invariant unobserved heterogeneity. Our FE estimates suggest that fathers' probability to support traditional gender norms declines by approximately three percentage points (8 percent change) when parenting primary school-aged daughters and by four percentage points (11 percent change) when parenting secondary school-aged daughters. In contrast, the effect on mothers' attitudes is smaller and generally not statistically significant. While it is not possible to discern the exact mechanisms through which daughters affect parental attitudes, the heterogeneity of results between fathers and mothers combined with the finding that attitudinal change occurs when daughters reach school age is in line with theories of exposure as well as with identity theories. Furthermore, given that attitudes towards gender norms are shaped by experiences during adulthood, our results provide evidence of intra-cohort change in attitudes. Consistent with our findings on attitudinal change, we find that parenting school-age daughters is also associated with a lower likelihood that couples follow a traditional gender division of work.

To the best of our knowledge, this is the first paper to explore the impact of a

[2]However, some authors such as Hamoudi & Nobles (2014) found that relationship conflict between husband and wife predicted the sex of subsequent children, and hence, separate analyses need to be done looking at the effect of the first child's sex only.

child's sex across daughters' ages on individual changes in attitudes towards gender norms. This is important because our findings suggest that it is when daughters are of school-age - and not before - that fathers' attitudes become less traditional, thus coinciding with the period in which children experience a stronger social pressure to conform to gender norms (Lane et al. 2017). The paper also contributes to expanding the evidence beyond the USA, being the first paper to explore the impact of the sex of the child on attitudes towards gender norms in the UK. Finally, and unlike previous studies, we draw on data that covers very recent years - up to 2012 - which is important given the large changes in patterns of gender inequalities during recent decades.

The structure of the paper is as follows. The next section reviews the relevant literature, and Section 4.3 describes the data and empirical strategy. Section 4.4 contains the main results, Section 4.5 robustness checks, and a final section concludes.

4.2 Related literature

4.2.1 On the malleability of attitudes towards gender norms

There are two main approaches in social science on the evolution of attitudes towards social norms, including gender norms. One approach suggests that attitudes are formed before reaching adulthood and remain stable thereafter.[3] Societal change in norms then occurs through processes of cohort succession, when older cohorts are replaced by younger ones who systematically differ in its social and historical early years' experiences (Mannheim 1952, Brooks & Bolzendahl 2004). An alternative approach - the one embraced by this paper - questions the stability of norms and embraces the viewpoint that attitudes can change over the life course, either due to social structural changes, or due to changes in individual circumstances (Brooks &

[3]See for example the increasing persistence hypothesis (Glenn 1980, Inglehart & Baker 2000) or the impressionable years hypothesis (Ryder 1965, Carlsson & Karlsson 1970, Krosnick & Alwin 1989).

Bolzendahl 2004, Hogg & Vaughan 2013, Baxter et al. 2015).[4]

Empirical evidence concerning these two approaches remains inconclusive. Two early papers analysing US data from the 1970s and the 1980s point in different directions, one suggesting that attitudes towards familial roles in the USA occur mainly within cohorts (Mason & Lu 1988) and another providing evidence for cohort replacement-based explanations (Wilkie 1993). Further analyses with data from the 1990s and early 2000s have not resolved the debate. While some research supports cohort replacement theories (Brewster & Padavic 2000), there is also evidence which confirms the importance of intra-cohort change (Danigelis et al. 2007). Another paper finds that while cohort replacement theories have a strong explanatory power, ideological learning during adulthood may mediate a large part of the cohort replacement effect (Brooks & Bolzendahl 2004).

Attention on intra-cohort change has recently shifted the focus of research towards the potential factors underpinning change, with a particular emphasis on family environment. To this purpose, longitudinal data has increasingly been used to study the impact on attitudes towards gender norms of women's decision to work (Cunningham 2008), parenthood (Evertsson 2013, Baxter et al. 2015), the interaction between work and childbirth (Berrington et al. 2008, Schober & Scott 2012), and marriage and cohabitation (Moors 2003, Corrigall & Konrad 2007). Nonetheless, the sex of the child has received limited attention. In what follows, we will focus on the specific effect of the sex of the child.

4.2.2 On the relevance of a child's sex for attitudes towards gender norms

Evidence on the effect of a child's sex on attitudes towards gender norms remains inconclusive.[5] Warner's (1991) pioneer study showed that daughters led Canadian

[4]See for example the life-stages hypothesis (Sears 1983, Visser & Krosnick 1998) or the lifelong openness hypothesis (Brim & Kagan 1980).

[5]In this paper, we focus on attitudes towards traditional gender norms as a dependent variable. A few papers from various disciplines have studied the effect of a child's sex on a range of other outcomes, among them parents' political party identification (Oswald & Powdthavee 2010, Lee &

and US parents to hold more modern attitudes towards gender norms (with the exception of American men). She explains her finding with the inclusion of children's well-being into parents' own utility function, consistent with (social) identity theory. The logic behind (social) identity theory is that individuals derive utility from behaving in line with the social roles and the social categories they identify with (see e.g. Hogg et al. 1995, Akerlof & Kranton 2000). Consistently, mothers with sons are more likely to hold traditional views on gender norms (Downey et al. 1994).[6]

Nonetheless, the external validity of those studies is limited due to small and unrepresentative samples sizes. In contrast, Shafer & Malhotra (2011) use a large sample (the National Longitudinal Study of Youth 1979 from the USA) and find that only fathers reduce their support for traditional gender roles when having a daughter, while mothers' attitudes remain unchanged. The intuition behind their finding is that mothers, unlike fathers, may have already crossed the 'threshold of exposure' by experiencing situations in their own lives that render them more sympathetic to a modern attitude towards gender norms.

Having a daughter would expose fathers to a larger extent than mothers to new worldviews, leading to a more significant shift in their attitudes. This evidence is in line with theories of exposure, which posit that individuals - parents, in this case - 'develop or change their understanding of women's place in society [...] when they encounter ideas and situations that resonate with feminist ideals' (Bolzendahl & Myers 2004, pp. 761-762). However, they cannot test the plausibility of exposure-related explanations, since they analyse the effect of childbirth as opposed to the effect of parenting daughters of different age groups. This is an important issue we address in this paper.

Conley 2016), voting behaviour on women's issues (Washington 2008, Glynn & Sen 2015), labour supply (Lundberg & Rose 2002, Lundberg 2005, Pabilonia & Ward-Batts 2007, Choi et al. 2008), take-up of parental leave (Bartel et al. 2018), support for gender equality policies (Warner & Steel 1999), and CEO's wage setting (Dahl et al. 2012). For an overview, see Lundberg (2005) and Raley & Bianchi (2006).

[6]Their explanations, however, are that sons are more valued than daughters, and that sons need more maternal attention, inducing mothers to think that working would be a disservice to them.

The significant effect of a child's sex on attitudes is challenged by two papers. Katzev et al. (1994) use the National Survey of Families and Households and find that, against their expectations, mothers with boys are more likely to hold modern attitudes towards marriage and family life. Similarly, Conley & Rauscher (2013), using the 1994 General Social Survey, find no evidence (for any parent) of daughters promoting non-traditional views and gender norms. The null effect would not necessarily contradict exposure-related theories given that if fathers exhibit a son preference,[7] they might spend less time with daughters and as a result be less exposed to their worldviews (Lee & Conley 2016). However, both studies are limited by either the older nature or the cross-sectional nature of the data, with findings potentially affected by time-invariant unobservables. The longitudinal nature of our data helps to overcome these limitations.

An additional advantage of large longitudinal evidence is that it allows for the examination of age-specific effects, which may play an important role. According to (social) identity theories, the event of a daughter's birth could be enough to trigger a readjustment of the parental utility to include their daughter's interests. However, it is possible that such readjustment only takes place once daughters are older and the consequences of gender norms on them become more visible. Research in psychology suggests that children are aware of gender stereotypes at the age of six already (Bian et al. 2017), with social pressure to conform to existing gender norms mounting around the early adolescence period (Lane et al. 2017). In line with theories of exposure (see Bolzendahl & Myers 2004, Glynn & Sen 2015), parents may thus start to become more aware of what is at stake for their daughters when they reach school-age, prompting a readjustment of their gender norm attitudes around this time (and not earlier). The rest of the paper will be devoted to understand empirically how the sex of the child influences parental attitudes across child age.

[7]Dahl & Moretti (2008) found a son preference in the USA using data from the 1960s to the 2000s. This son preference is less evident in more recent US data (see Blau et al. 2020).

4.3 Data and empirical strategy

We use rich longitudinal data from the British Household Panel Survey (BHPS) together with the BHPS sample of the UK Household Longitudinal Study (UKHLS). The BHPS was collected annually from 1999 to 2008 and became part of the new UKHLS, which started in 2009 and is still ongoing (University of Essex 2015). The data are a nationally representative sample of British households collected annually since 1991. Attitudes towards the gender division of work - our outcome variable of interest - were collected biennially, hence our data comprise 11 distinct waves covering the period from 1991 to 2012.

4.3.1 Sample

We restrict the sample to individuals who we observe with a child under the age of 21 in the household in at least one wave, thus excluding individuals who never have children in the household as well as individuals who are only observed after their children in the household are already in their twenties or older. Since we follow individuals over time and are interested in the variation from children entering the household and not the variation from children leaving the household, we follow individuals only as long as the number of children in the household is increasing or constant.[8] After dropping observations for which the main outcome variable or any of the covariates are missing, the final sample is an unbalanced panel including 48,822 observations of 11,405 individuals (5,073 men with 20,851 observations and 6,332 women with 27,971 observations).

4.3.2 Measures

Our dependent variable measures attitudes towards traditional gender norms, specifically towards a traditional gender division of work. Respondents are asked to rate agreement with the statement 'a husband's job is to earn money; a wife's job is to

[8]We replicated the main results of section four without this further sample restriction and results remained similar.

look after the home and family' on a 5-point scale ranging from 'strongly agree' to 'strongly disagree'. We recoded the answers so that higher values mean stronger agreement with the statement, hence more traditional attitudes. We focus on this attitudinal question as it captures the essence of the traditional male breadwinner norm, by which it is the husband's role to work and the wife's role to stay at home. We also binarize the dependent variable into non-traditional (taking a value of zero for 'disagree' or 'strongly disagree') and traditional (taking a value of one for 'neither agree nor disagree', 'agree', and 'strongly agree') and report results alongside those for the ordinal dependent variable.[9]

Our main regressor of interest is the binary variable 'at least one daughter' that takes on a value of one if the respondent has at least one daughter living in the household, and zero otherwise.[10] To account for the potential interactive effect between sex and age of the child on attitudes to gender norms, we also distinguish different age groups: 'daughter 0 to 5', 'daughter 6 to 10', and 'daughter 11 or older' are dummy variables indicating whether there is at least one daughter of the respective age group living in the household. If there is more than one daughter, we consider the age of the youngest daughter, but we also run a robustness check using age of the oldest daughter. We refer to these age groups as preschool-aged daughters, primary school-aged daughters, and secondary school-aged daughters, and to refer to the latter two at the same time we say school-aged daughters.

Our data contain information on children living in the household (as opposed to fertility records) which we use to construct our daughters measures, and we equally consider biological children, adopted children, foster children, and partners'/step-children.[11] Since we are interested in the longitudinal effect of parenting daughters via exposure or identity changes rather than the one-time event of a birth of a daughter, we consider information from co-residence preferable over that from fer-

[9]We also ran the main results (Tables 4.2 and 4.3) when considering 'neither agree nor disagree' as non-traditional and results remained similar, albeit with generally smaller effect sizes.

[10]In a robustness check in Table 4.6, we use alternative ways to represent sex of the child.

[11]94.4 percent of our children-wave pairs are on biological children, 4.8 percent on step/partners' children, 0.7 percent on adopted children, and 0.2 percent on foster children. If anything, we expect our results to be downward biased compared to considering only biological children.

tility histories.

4.3.3 Estimation approach and identification assumptions

We are interested in identifying the effect of parenting daughters on parental attitudes towards gender norms, and start by estimating the following pooled OLS baseline specification:

$$y_{it} = \alpha + \beta_1 d_{it} + \beta_2 (d_{it} * fem_{it}) + \beta_3 fem_{it} + \beta_4 c_{it} + \beta_5 X_{it} + \beta_6 T_t + \varepsilon_{it} \quad (4.1)$$

where y_{it} stands for the level of agreement with traditional gender norms of individual i at time t, fem_{it} is a dummy variable indicating the individual is female, c_{it} are dummy variables controlling for the total number of children in the household, X_{it} are a set of individual characteristics, and T_t are wave fixed effects. d_{it} is our key regressor for parenting daughters and takes two forms. Once a dummy with a value of one if the individual has at least one daughter in the household, and zero otherwise. In a second specification testing age-of-daughter specific effects, d is a categorial variable, and we include three dummies for the categories 'at least one daughter with the youngest aged zero to five years', 'at least one daughter with the youngest aged six to ten years', and 'at least one daughter with the youngest aged at least eleven years'. Robust standard errors are clustered by individual.

Thus, we estimate the effect of parenting at least one daughter, while holding family size constant. When the number of children is controlled for, the coefficient on the daughter dummy captures the additional effect of parenting daughters as opposed to parenting only sons. In all models, we interact the effect of parenting daughters with a dummy for females, thus allowing the effect of parenting daughters to vary by sex of the parent. We then start adding control variables in a stepwise fashion: first, by adding the 'basic controls' age, square of age, as well as region and wave FEs. Then, by additionally adding the 'additional controls', which consist of two educational level dummies, five marital status dummies, eight employment

status dummies, and the natural logarithm of household income (see Table 4.A.2 in Appendix 4.A for summary statistics and definitions of all variables).

While estimates from pooled OLS regressions are comparable to previous literature that uses cross-sectional data, we also estimate individual FE models with robust standard errors, in order to eliminate bias arising from unobserved individual heterogeneity and to capture the effect of daughters on changes in attitudes within individuals longitudinally rather than comparing those with to those without daughters.[12] Hence, the error term in equation 4.1 takes the form:

$$\varepsilon_{it} = \mu_i + \rho_{it} \tag{4.2}$$

We follow previous literature (e.g. Washington 2008, Oswald & Powdthavee 2010) in considering the sex of any given child entering the household as approximately random. This is based on the argument that parents cannot choose the sex of any given child, absent sex-selective abortion. Previous literature has regarded the possibility of sex-selective abortion as empirically unimportant in Western countries (Choi et al. 2008). However, we still face potential endogeneity because of three reasons. First, fertility stopping rules may depend on the sex mix of children already in the household, hence our key regressor of having at least one daughter conditional on the total number of children may be selected. Indeed, evidence suggests that parents in Western countries including the UK are more likely to have a third child if their first two children are of the same sex, as they prefer a 'balanced' sex mix of children (Iacovou 2001, Lundberg 2005). There is also some evidence suggesting that a firstborn boy increases the probability of further children (Ichino et al. 2014). This implies that only the sex of a firstborn child is truly random, and if more (less) traditional parents have a son (daughter) preference, this would introduce an upward bias to our OLS estimates. To account for these possibilities, we perform robustness checks in which we test for endogenous fertility stopping rules. We also

[12]For ease of interpretation we estimate linear models, but our results remain very similar when we re-estimate the main results for the binarized dependent variable with logit and fixed effects logit models (see Table 4.A.4).

estimate the effect of the sex of the first child only on attitudes, and we re-estimate the main results on the subsample of observations with two or less children.

Second, there is potential selection into co-residence with daughters because a father's or mother's decision about co-residence may depend upon whether they have daughters or sons. For example, after couples split, we typically observe the resident parent with marital status 'divorced', while the non-resident parent drops out of our estimation sample.[13] Then, if the likelihood to divorce or to get child custody depends on a child's sex, this may bias our results.[14] Therefore, this essentially becomes a problem of attrition and we perform robustness checks testing whether having daughters is related to attrition and whether attrition affects our results. We also re-estimate the main results on the subsample of never-divorcees and never-attritors.

Finally, we also check that our results are not driven by reverse causality, that is, that initial attitudes predict the probability of having a daughter. In addition to performing these robustness checks, we note that FEs account for the bias arising from time-invariant unobservable characteristics that are correlated with both the probability to live with daughters and with attitudes. For our FE estimates to still be biased, it would be necessary that the timing of daughters entering the household is systematically correlated with shocks causing attitudinal change. Or alternatively, that individuals with higher malleability in attitudes are more likely to live with daughters versus sons. We argue that this is unlikely. In line with this, Amato & Booth (1991) find that individuals in the US who were divorced at baseline held less traditional gender role attitudes, while getting divorced during the duration of the panel was not associated with changes in attitudes. We are, however, not aware of

[13]This happens due to one of two reasons, either because they attrit from the panel due to the inability to track or retain the non-resident parent in the study after the family splits, or because we drop observations on non-resident parents as we follow individuals only as long as the number of children in the household is increasing or constant. We replicated the main results reported in section 4.4, keeping the observations for which variation came from children leaving the household, and results remained similar.

[14]However, there seems to be no evidence of an association between children's sex and divorce or custody arrangements in Western countries other than the USA (Lundberg 2005) and we are not aware of any UK study investigating this.

any UK evidence on this issue.

4.3.4 Sample descriptive statistics and randomization checks

Table 4.A.2 in Appendix 4.A reports summary statistics for the analysis sample. The average age of observations for men and women in our sample is 37.5 and 35.4 years, respectively. The average number of children is 1.62 and 1.66, respectively. The dummy of having at least one daughter in the household takes a value of one for 57 percent of observations on men and 58 percent of observations on women. The various variables on daughters in the household (at least one daughter, only daughters, first daughter) are very similar between males and females and suggest that there are no substantial differences between fathers and mothers in their probability to co-reside with daughters.

Figure 4.1 examines how attitudes towards the gender division of work differ by respondent sex and by the sex composition of offspring for individual-wave pairs with at least one child in the household. It shows the mean value of the ordinal (Panel a) and binarized (Panel b) outcome variable. On average, men have higher levels of agreement with the traditional male breadwinner norm than women. Men with at least one daughter or only daughters are less traditional than men with only sons. Women with daughters only are less traditional than women with sons only, but those with at least one daughter actually appear more traditional compared to those with only sons. To understand whether these differences are explained by other covariates requires further analysis.

In Table 4.1 we check whether our key regressor of parenting at least one daughter is related to any socio-demographic characteristics. In panel a, each row shows the coefficient of a separate regression of the probability to have at least one daughter on the respective socio-demographic characteristic, while controlling for the total number of children. Most of the individual characteristics are unrelated to the probability of parenting daughters, with a few exceptions. For females, having a higher degree is positively associated with parenting daughters, while being widowed/other

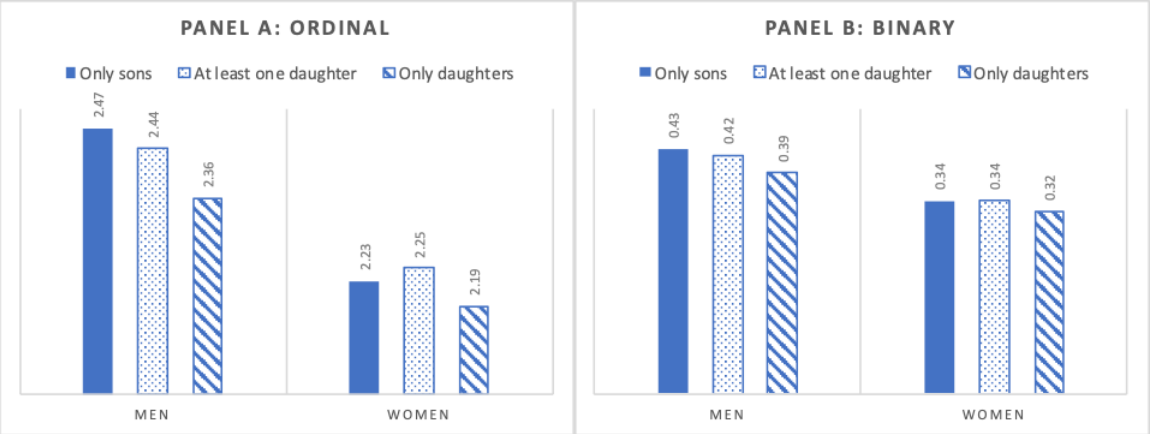

Figure 4.1: Mean attitudes towards traditional gender division of work

Notes: Sample restricted to individual-wave pairs with at least one child in the household. Panel a shows mean levels of agreement with the statement 'husband should work and wife stay at home' (scale 1 to 5), by the sex composition of children. Panel b shows the share of observations with 'traditional attitudes' when the dependent variable is binarized, by the sex composition of children. Source: Authors' calculations based on BHPS and UKHLS data.

marital status, being retired, and being in government training/having another employment status is negatively associated with parenting daughters. For men, being divorced is associated with a lower probability to be parenting daughters. To account for these differences, we control for marital status, employment status, and educational level. Panel b tests whether all socio-demographic characteristics shown in panel a, plus region and wave FEs, can predict having at least one daughter while holding family size constant. The F-test rejects joint significance for both the male and the female subsample. This supports our assumption of no selection into having at least one daughter, conditional on family size.

4.4 Results

Our main results are presented in Tables 4.2 to 4.4. Table 4.2 estimates the effect of parenting daughters on attitudes towards the traditional gender division of work. Table 4.3 subdivides this effect into parenting daughters of three different age groups. Finally, Table 4.4 studies whether parenting daughters is also associated

Table 4.1: Randomisation checks

	(1) Male	(2) Female
Panel a: randomisation checks		
Age	-0.0006	-0.0007
	(0.0007)	(0.0006)
Age squared	0.0000	0.0000
	(0.0000)	(0.0000)
First degree	-0.0137	-0.0123
	(0.0173)	(0.0158)
Higher degree	0.0234	0.0566**
	(0.0298)	(0.0277)
Ln household income	-0.0018	-0.0039
	(0.0062)	(0.0056)
Marital status: married	-0.0001	-0.00162
	(0.0118)	(0.0103)
Marital status: living as couple	0.0149	0.0047
	(0.0122)	(0.0111)
Marital status: widowed/other	0.0183	-0.108**
	(0.0848)	(0.0434)
Marital status: divorced	-0.103**	0.0234
	(0.0406)	(0.0198)
Marital status: separated	-0.0364	0.0181
	(0.0347)	(0.0226)
Marital status: never married	-0.0043	-0.0096
	(0.0038)	(0.0133)
Empl. Status: self-employed	-0.0205	-0.0240
	(0.0146)	(0.0225)
Empl. Status: in paid employment	0.0139	0.0028
	(0.0105)	(0.0086)
Empl. Status: unemployed	-0.0119	0.0010
	(0.0144)	(0.0146)
Empl. Status: retired	-0.0036	-0.146**
	(0.0549)	(0.0600)
Empl. Status: family care	0.0956	0.0069
	(0.0850)	(0.0115)
Empl. Status: FT student	-0.0109	0.0021
	(0.0315)	(0.0102)
Empl. Status: LT sick/disabled	0.0045	-0.0070
	(0.0131)	(0.0118)
Empl. Status: maternity leave	0.0100	0.0344
	(0.0293)	(0.0245)
Empl. Status: gov't training/other	0.0131	-0.0533*
	(0.0331)	(0.0314)
Observations	20,851	27,971
Panel b: F-test of joint significance of long regression		
Joint F-statistic	1.06	1.28
p-value	0.36	0.11

Notes panel a: Robust standard errors in parentheses, clustered by individual. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The different rows are separate pooled OLS regressions with having at least one daughter as the dependent variable. All specifications include 4 dummy variables for number of children. Notes panel b: F-test of joint significance of covariates shown in panel a, plus region and wave fixed effects. Sources: BHPS, UKHLS.

with couples' probability of following a traditional gender division of work.

4.4.1 Main results

Table 4.2 presents the effect of parenting daughters on levels of agreement with the traditional male breadwinner norm, using the continuous attitudinal scale of the survey as well as a binarized version to capture potential 'attitudinal shifts'. In columns 1 to 3 and 5 to 7 the dependent attitude variable is ordinal, while in columns 4 and 8 it is binarized. In all specifications we include dummy variables for the total number of children in the household, hence we identify the effect of parenting at least one daughter while holding family size constant. We only report the coefficients on the variables of key interest. For full results showing coefficients on all control variables see Table 4.A.1 in Appendix 4.A. We allow the effect to vary by sex of the parent as we interact the daughter dummy with a female dummy, and in addition to the interaction term we report the direct effect of parenting daughters for mothers via linear combination of estimates.

Table 4.2: Effect of parenting daughters on attitudes to gender norms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS				Fixed Effects			
	Ordinal dep. variable			binary	Ordinal dep. variable			binary
At least one daughter	-0.113***	-0.119***	-0.0930***	-0.0310***	-0.0547**	-0.0571**	-0.0415	-0.0102
	(0.0255)	(0.0249)	(0.0242)	(0.0115)	(0.0270)	(0.0271)	(0.0271)	(0.0140)
Female	-0.276***	-0.263***	-0.295***	-0.117***				
	(0.0235)	(0.0231)	(0.0223)	(0.0102)				
At least one daughter x female	0.0803***	0.0963***	0.0495*	0.0063	0.0919***	0.0905***	0.0626**	0.0091
	(0.0294)	(0.0290)	(0.0280)	(0.0130)	(0.0300)	(0.0300)	(0.0302)	(0.0156)
Linear combination of estimates: effect for females								
At least one daughter	-0.0330	-0.0228	-0.0435**	-0.0247**	0.0373	0.0334	0.0212	-0.00111
	(0.0227)	(0.0223)	(0.0210)	(0.00976)	(0.0257)	(0.0257)	(0.0256)	(0.0133)
Total number of children controls	yes	yes	yes	yes	yes	yes	yes	yes
Basic controls		yes	yes	yes		yes	yes	yes
Additional controls			yes	yes			yes	yes
Observations	48,822	48,822	48,822	48,822	48,822	48,822	48,822	48,822
R-squared	0.041	0.061	0.106	0.075	0.006	0.009	0.013	0.010
Number of individuals					11,405	11,405	11,405	11,405

Notes: Robust standard errors in parentheses (clustered by individual for columns (1) to (4)). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Total number of children controls: 4 dummies for number of total children. Basic controls: age, age squared, wave dummies, region dummies. Additional controls: 2 education dummies, 5 marital status dummies, 8 employment status dummies, ln household income. Sources: BHPS, UKHLS.

We find that having daughters is associated with lower levels of agreement with traditional gender norms among men, but not among women as reflected in column 1. Next, we add age, square of age, as well as wave and region FEs in column 2 and we observe that results are robust to such controls. In column 3 we additionally control for education, marital status, employment status, and the natural logarithm of household income. Importantly, the negative association between parenting daughters and traditional attitudes remains after controlling for these observable characteristics. Results hold too when attitudes are binarized in column 4, and we show that men with daughters are approximately three percentage points less likely to hold traditional attitudes compared to men without daughters, while holding family size constant. This coefficient reflects an 8 percent reduction in the probability to hold traditional attitudes.[15]

Given that these results could be explained by individual specific and time invariant unobservables that affect both co-residence with daughters and attitudes, columns 5 to 8 exhibit the individual FE results and show that the negative association between parenting daughters and traditional attitudes persists in FE models. Comparing the FE columns with their respective OLS ones reveals that the size of the coefficient is approximately halved when accounting for time-invariant unobserved heterogeneity. Once we introduce the 'additional controls' for education, marital status, employment status, and ln household income in columns 7 and 8, the coefficient on the daughter dummy becomes statistically insignificant although the sign remains.

We then turn to examine attitudes among women. Women hold on average less traditional attitudes compared to men. The interaction effects between parenting daughters and being female show that the effect of parenting daughters is significantly different for mothers compared to fathers when the outcome variable is ordinal. The linear combinations of estimates capture the overall effect of parenting daughters among women. OLS estimates (columns 1 to 4) show that parenting

[15] Approximately 37.1 percent of male observations without daughters in our sample hold traditional attitudes.

daughters is also negatively associated with traditional attitudes among women, the effect is smaller compared to the one for men and statistically significant only in two of the columns. When individual FEs are included, the coefficient on the daughter dummy is statistically insignificant in all specifications and the sign even turns positive for the specifications with ordinal dependent variable (columns 5 to 7).

Taken together, the results suggest that having daughters is associated with lower levels of agreement with traditional gender norms among men. For women, the association is ambiguous. Once controlling for the full set of observable characteristics and time-invariant unobservable characteristics in columns 7 and 8, effects for both males and females are not statistically significant. This suggests that, on average, attitudes do not change with the birth of a daughter.

4.4.2 Age-of-daughter specific effects

Given that rearing a daughter might not exert an immediate effect on attitudes upon birth but instead may emerge after a certain exposure, we next turn to examining age-of-daughter specific effects of rearing daughters on parental gender norm attitudes (Table 4.3). We separate our previous dummy on parenting daughters into three different dummy variables: 'at least one daughter of age group 0 to 5', 'at least one daughter of age group 6 to 10', and 'at least one daughter of age group 11 or older'.[16] We refer to them in our paper as pre-school, primary school, and secondary school-age daughters. Consistently with Table 4.2, the omitted category is thus 'not parenting any daughters'.

[16]If there is more than one daughter, we define the age group based on the youngest daughter in the household, and we perform robustness checks in which we define the age group based on the oldest daughter in the household (see Table 4.6).

Table 4.3: Effect of parenting daughters of different age groups on attitudes to gender norms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS				Fixed Effects			
	Ordinal dep. variable			binary	Ordinal dep. variable			binary
At least one daughter (youngest 0 to 5)	-0.158***	-0.107***	-0.0659**	-0.0165	-0.0468*	-0.0474*	-0.0295	-0.0031
	(0.0277)	(0.0276)	(0.0271)	(0.0129)	(0.0274)	(0.0274)	(0.0275)	(0.0142)
At least one daughter (youngest 6 to 10)	-0.162***	-0.144***	-0.120***	-0.0480***	-0.0703**	-0.0790**	-0.0625*	-0.0281*
	(0.0308)	(0.0301)	(0.0296)	(0.0144)	(0.0322)	(0.0324)	(0.0324)	(0.0170)
At least one daughter (youngest 11 plus)	-0.0375	-0.116***	-0.103***	-0.0348**	-0.106***	-0.124***	-0.110***	-0.0410**
	(0.0307)	(0.0307)	(0.0297)	(0.0141)	(0.0344)	(0.0359)	(0.0359)	(0.0187)
Female	-0.276***	-0.263***	-0.296***	-0.118***				
	(0.0235)	(0.0232)	(0.0223)	(0.0103)				
Daughter 0 to 5 x female	0.0926***	0.0818**	-0.0074	-0.0222	0.0900***	0.0887***	0.0519*	0.0030
	(0.0336)	(0.0332)	(0.0322)	(0.0150)	(0.0307)	(0.0307)	(0.0309)	(0.0159)
Daughter 6 to 10 x female	0.0986***	0.116***	0.0811**	0.0216	0.0952**	0.0920**	0.0821**	0.0218
	(0.0368)	(0.0364)	(0.0353)	(0.0168)	(0.0370)	(0.0371)	(0.0372)	(0.0195)
Daughter 11 plus x female	0.0540	0.0976***	0.0832**	0.0235	0.0905**	0.0862**	0.0851**	0.0205
	(0.0366)	(0.0361)	(0.0347)	(0.0164)	(0.0418)	(0.0420)	(0.0421)	(0.0216)
Linear combination of estimates: effect for females								
At least one daughter (youngest 0 to 5)	-0.0653**	-0.0252	-0.0733***	-0.0387***	0.0432*	0.0413	0.0225	-0.0001
	(0.0255)	(0.0256)	(0.0242)	(0.0110)	(0.0259)	(0.0260)	(0.0259)	(0.0134)
At least one daughter (youngest 6 to 10)	-0.0632**	-0.0276	-0.0389	-0.0264**	0.0248	0.0130	0.0195	-0.0063
	(0.0270)	(0.0267)	(0.0253)	(0.0119)	(0.0299)	(0.0302)	(0.0301)	(0.0156)
At least one daughter (youngest 11 plus)	0.0166	-0.0187	-0.0195	-0.0113	-0.0151	-0.0374	-0.0249	-0.0205
	(0.0264)	(0.0268)	(0.0254)	(0.0120)	(0.0332)	(0.0351)	(0.0350)	(0.0177)
Total number of children controls	yes	yes	yes	yes	yes	yes	yes	yes
Basic controls		yes	yes	yes		yes	yes	yes
Additional controls			yes	yes			yes	yes
Observations	48,822	48,822	48,822	48,822	48,822	48,822	48,822	48,822
R-squared	0.042	0.061	0.106	0.076	0.006	0.010	0.014	0.010
Number of individuals					11,405	11,405	11,405	11,405

Notes: Robust standard errors in parentheses (clustered by individual for columns (1) to (4)). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Total number of children controls: 4 dummies for number of total children. Basic controls: age, age squared, wave dummies, region dummies. Additional controls: 2 education dummies, 5 marital status dummies, 8 employment status dummies, ln household income. Sources: BHPS, UKHLS.

The OLS estimates suggest that parenting daughters of each age group is associated with less traditional gender attitudes among fathers, but the effect is larger for daughters of school-age (age groups 6 to 10 and 11 plus) rather than pre-school, which is consistent with exposure-based explanations. As expected, when we control for individual FEs (columns 5 to 8), the coefficients on pre-school daughters and primary school daughters shrink. In the full specification in column 7, the coefficient on daughters aged 0 to 5 becomes insignificant, suggesting that on average, attitudes do not change at birth. In contrast, results suggest that parenting daughters of primary and secondary school-age makes fathers on average less traditional, with a larger effect size for secondary school-age daughters. Consistently, results for the binarized outcome variable in column 8 indicate that parenting pre-school daughters does not affect fathers' attitudes, while parenting primary school-age daughters reduces the probability to hold traditional attitudes by about three percentage points, which constitutes an 8 percent change compared to the baseline probability of holding traditional attitudes of 37.1 percent among men without daughters. Parenting secondary school-age daughters reduces the probability to hold traditional attitudes by approximately four percentage points, which amounts to an 11 percent change compared to men without daughters.

As before, we then turn to examining the effects for mothers. The interactions between the different daughter dummies and the female dummy show that in many cases, the effect of parenting daughters is significantly different for mothers. When we test the joint significance of the linear combination of estimates, OLS estimates in columns 1 to 4 suggest that parenting pre-school and primary school daughters is associated with less traditional attitudes among mothers. However, once we introduce individual FEs the effect of parenting daughters on attitudes becomes insignificant for all age groups, while the sign of the coefficients turns positive for the younger two age groups.

Taken together, results from Table 4.3 suggest that after accounting for time-invariant unobserved heterogeneity, there is no robust effect among mothers. For fathers, attitudes to gender norms do not change with the birth of a daughter but in-

stead, fathers' attitudes become significantly less traditional when parenting school-age daughters.

4.4.3 Effects on behaviour

Given these interesting results for men, we next explore whether parenting daughters is also associated with behavioural changes reflecting the male breadwinner norm as it would be expected if attitudes inform behaviours (Table 4.4). To do so, we focus on the subsample of males living in a couple, and we define a variable which takes the value of one if the individual is employed or self-employed and the partner is neither of the two, and a value of zero otherwise.

We find that on average, having daughters does not change the probability to follow a male breadwinner norm (column 1 for OLS and 3 for FE). Studying different age groups again yields a more differentiated picture though. Parenting pre-school daughters is associated with a higher probability to behave traditionally. However, parenting primary and secondary school-age daughters is associated with a lower likelihood to follow a traditional male breadwinner norm in which the man works and the woman does not work, and this result holds both cross-sectionally and longitudinally. In terms of effect size, FEs estimates shown in column 4 indicate that parenting daughters aged six to 10 reduces the probability of a traditional gender division of work by seven percentage points, and parenting daughters aged 11 or older reduces that probability by five percentage points. Compared to the baseline probability of following a traditional norm for those without daughters of 20.3 percent, this is a sizeable reduction of 36 percent and 25 percent, respectively. Therefore, our finding that parenting daughters changes attitudes to gender norms is also reflected in behavioural changes concerning gender norms, for the subsample of individuals living with a partner.

Table 4.4: Effect of parenting daughters on the traditional gender division of work (male subsample)

	(1)	(2)	(3)	(4)
	Pooled OLS		Fixed Effects	
Dependent variable	Traditional gender division of work			
At least one daughter	-0.0172		0.0000	
	(0.0118)		(0.0194)	
At least one daughter (youngest aged 0 to 5)		0.0699***		0.0122
		(0.0137)		(0.0196)
At least one daughter (youngest 6 to 10)		-0.0653***		-0.0724***
		(0.0141)		(0.0218)
At least one daughter (youngest 11 plus)		-0.0849***		-0.0507**
		(0.0139)		(0.0248)
Observations	18,144	18,144	18,144	18,144
R-squared	0.064	0.078	0.077	0.082
Number of individuals			4,889	4,889

Notes: Robust standard errors in parentheses (clustered by individual for columns (1) to (2)). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables in all columns: 4 dummies for number of total children, age, age squared, 2 education dummies, 5 marital status dummies, ln household income, wave dummies, region dummies. Outcome variable: Dummy individual (self-)employed and partner not (self-)employed. Sources: BHPS, UKHLS.

4.5 Robustness checks

Given the results in Section 4.4, we next examine the robustness of our main findings in a number of different ways. We include the full set of covariates, so the estimates are comparable to those in columns 3 (OLS) and (7) (FE) of Tables 4.2 and 4.3.

4.5.1 Endogenous fertility and reverse causality

We start by exploring in how far our results are affected by endogenous fertility stopping rules. In panel a of Table 4.5, we examine whether the sex of the first child (columns 1 and 3) and the sex mix of the first two children (columns 2 and 4) in the household predict the total number of children an individual has in the last wave he or she appears in the estimation sample. To do so, we construct a collapsed cross-sectional data set in which we only keep one observation per individual and summarize information from different survey waves. We analyse the male and female subsamples separately.

We find that there is a negative but not statistically significant association be-

Table 4.5: Testing for endogenous fertility stopping rules and reverse causality

Panel a: Does the sex mix of existing children predict total number of children?				
	(1)	(2)	(3)	(4)
	Number of children			
	Male		Female	
Ever 1stdaughter	-0.0386		-0.0149	
	(0.0261)		(0.0236)	
First two children: at least 1 daughter		-0.0820***		-0.0730***
		(0.0294)		(0.0271)
Observations	5,073	3,618	6,332	4,422
R-squared	0.081	0.068	0.121	0.079

Panel b: Do initial attitudes predict ever having a daughter?				
	(1)	(2)	(3)	(4)
	Ever a daughter			
	Male		Female	
Initial attitude: gender division of work	-0.0026		0.0038	
	(0.0060)		(0.0053)	
Observations	5,073		6,332	
R-squared	0.117		0.118	

Notes: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Controls in all panels & columns: age, age square, 2 education dummies, ln HH income, 5 marital status dummies, 8 employment status dummies, wave dummies, and region dummies. Additional controls in panel b: 3 dummies number of total children. Sources: BHPS, UKHLS.

tween having a first daughter and the total number of children for both men and women. The key regressor labelled 'ever1stdaughter' takes a value of one if in at least one survey wave the oldest child is female, and zero otherwise. The dependent variable is the total number of children the individual has in the last wave he or she appears in the estimation sample. However, we do find a negative and statistically significant correlation between having at least one daughter among the two oldest children and the number of total children, for the subsample of individuals who have at least two children by the last wave. The key regressor is a binary variable taking a value of one if there is at least one daughter among the two oldest children in the household in the last wave the individual is included in the estimation sample, and zero if they are both sons. This implies that those who have two sons are more likely to have further children compared to those with at least one daughter and hence there is positive selection of having at least one daughter. This is in line with

previous research which shows that parents prefer having offspring with a balanced sex mix (Iacovou 2001, Lundberg 2005). To make sure this is not driving our results, we examine the effect of the sex of the oldest child only (Table 4.6) and we analyse the subsample of individual-wave pairs with two or less children only (Table 4.7), and we find that our results are robust to these additional checks.

Specifically, in Table 4.6, we examine the robustness of our findings from Table 4.3 to three alternative specifications of the key regressors. These are dummy variables taking a value of one if there are only daughters of the respective age group in the household (columns 1 and 2), if the oldest child in the household is female and in the respective age group (columns 3 and 4), and if there is at least one daughter with the age group based on the oldest daughter (columns 5 and 6), respectively, and zero otherwise.

Table 4.6: Alternative key regressors

	(1)	(2)	(3)	(4)	(5)	(6)
Key regressor	Only daughters		Oldest child female		At least one daughter	
Age group based on	youngest daughter		oldest daughter		oldest daughter	
	Pooled OLS	FEs	Pooled OLS	FEs	Pooled OLS	FEs
Daughter (age 0 to 5)	-0.0552*	-0.0339	-0.0282	-0.0204	-0.0616**	-0.0304
	(0.0313)	(0.0296)	(0.0314)	(0.0346)	(0.0272)	(0.0276)
Daughter (age 6 to 10)	-0.108**	-0.0675	-0.0709**	-0.0371	-0.108***	-0.0550*
	(0.0425)	(0.0431)	(0.0326)	(0.0361)	(0.0298)	(0.0323)
Daughter (age 11 plus)	-0.113***	-0.158***	-0.0581**	-0.0909**	-0.104***	-0.109***
	(0.0393)	(0.0467)	(0.0281)	(0.0388)	(0.0287)	(0.0358)
Female	-0.283***		-0.279***		-0.296***	
	(0.0177)		(0.0195)		(0.0223)	
Daughter 0 to 5 x female	0.0203	0.0471	-0.0311	0.0753*	-0.0138	0.0478
	(0.0390)	(0.0360)	(0.0384)	(0.0401)	(0.0325)	(0.0313)
Daughter 6 to 10 x female	0.111**	0.0684	0.0493	0.0964**	0.0653*	0.0770**
	(0.0525)	(0.0540)	(0.0412)	(0.0451)	(0.0356)	(0.0365)
Daughter 11 plus x female	0.111**	0.111*	0.0493	0.119**	0.0791**	0.100**
	(0.0481)	(0.0606)	(0.0354)	(0.0489)	(0.0332)	(0.0408)
Linear combination of estimates: effect for females						
Daughter (age 0 to 5)	-0.0349	0.0132	-0.0593**	0.0549*	-0.0754***	0.0174
	(0.0282)	(0.0277)	(0.0274)	(0.0317)	(0.0241)	(0.0259)
Daughter (age 6 to 10)	0.0039	0.0010	-0.0216	0.0592	-0.0429*	0.0219
	(0.0327)	(0.0373)	(0.0272)	(0.0360)	(0.0256)	(0.0309)
Daughter (age 11 plus)	-0.0021	-0.0466	-0.0088	0.0278	-0.0246	-0.0088
	(0.0314)	(0.0444)	(0.0238)	(0.0389)	(0.0249)	(0.0354)
Observations	48,822	48,822	48,822	48,822	48,822	48,822
R-squared	0.106	0.014	0.106	0.014	0.106	0.014
Number of individuals		11,405		11,405		11,405

Notes: Robust standard errors in parentheses (clustered by individual for pooled OLS estimates). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables in all columns: 4 dummies for number of total children, age, age squared, 2 education dummies, 5 marital status dummies, 8 employment status dummies, ln household income, wave dummies, region dummies. Sources: BHPS, UKHLS.

We find that the results from these alternative specifications are very similar to those obtained in Table 4.3. Overall, having daughters is negatively and significantly associated with less traditional attitudes among men, and the effect for secondary school-age daughters is robust to the inclusion of individual FEs. For women, the negative and mostly insignificant association between having daughters and traditional attitudes becomes positive for the two younger age groups and generally insignificant with FEs. The coefficients indicating the effect among fathers are largest for parenting only daughters and smallest when we only consider the sex of the first child, consistently with an exposure-based explanation. In sum, the robustness of our main results to considering only the sex of the oldest child suggests that they are not driven by endogenous fertility stopping rules. Moreover, we argue that it would be difficult for an individual to select into having only daughters, having at least one daughter, and having a firstborn daughter, all while holding family size constant. Therefore, results from Table 4.6, when taken together, provide further support that our findings are not driven by endogenous fertility stopping rules.

Another way to test that our results are not driven by endogenous fertility stopping rules based on the sex mix of the first two children is to examine results for the subsample of individual-wave pairs with two or less children (columns 1 to 4 of Table 4.7). Results for the subsample are very similar to the main results, providing a further indication that endogenous fertility stopping rules are not the driver behind our findings.

In panel b of Table 4.5, we test for the possibility of reverse causality. We run regressions of 'ever having at least one daughter' on initial gender attitudes in the first wave the individual was interviewed while controlling for the full set of covariates, including the total number of children. We find that initial attitudes are not associated with the probability of ever having a daughter while holding family size constant and hence, there is no evidence of reverse causality.

Table 4.7: Different subsamples

Subsample	Two or less children				Never-divorcees				Never-attritors			
	Pooled OLS		Fixed effects		Pooled OLS		Fixed effects		Pooled OLS		Fixed effects	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Daughter	-0.101***		-0.0427		-0.102***		-0.0459*		-0.0815*		-0.0678*	
	(0.0260)		(0.0298)		(0.0248)		(0.0278)		(0.0426)		(0.0377)	
Female	-0.293***	-0.295***			-0.296***	-0.298***			-0.290***	-0.290***		
	(0.0228)	(0.0228)			(0.0232)	(0.0232)			(0.0344)	(0.0344)		
Daughter x female	0.0656**		0.0704**		0.0507*		0.0602*		0.0257		0.0855**	
	(0.0303)		(0.0324)		(0.0290)		(0.0311)		(0.0459)		(0.0405)	
Daughter 0-5		-0.0764***		-0.0307		-0.0760***		-0.0364		-0.0680		-0.0614
		(0.0287)		(0.0302)		(0.0276)		(0.0281)		(0.0431)		(0.0384)
Daughter 6-10		-0.115***		-0.0531		-0.132***		-0.0683**		-0.0877*		-0.0885*
		(0.0340)		(0.0365)		(0.0302)		(0.0333)		(0.0510)		(0.0467)
Daughter 11+		-0.116***		-0.122***		-0.109***		-0.108***		-0.105*		-0.116**
		(0.0326)		(0.0407)		(0.0305)		(0.0372)		(0.0625)		(0.0553)
Daughter 0-5 x female		0.0069		0.0601*		-0.0008		0.0521		0.0140		0.0846**
		(0.0342)		(0.0332)		(0.0332)		(0.0318)		(0.0483)		(0.0416)
Daughter 6-10 x female		0.0823**		0.0812*		0.0797**		0.0779**		0.0351		0.0910*
		(0.0412)		(0.0421)		(0.0366)		(0.0386)		(0.0569)		(0.0527)
Daughter 11+ x female		0.112***		0.115**		0.0824**		0.0737*		0.0415		0.0818
		(0.0384)		(0.0473)		(0.0363)		(0.0441)		(0.0692)		(0.0635)
Linear combination of estimates: effect for females												
Daughter	-0.0353		0.0278		-0.0513**		0.0142		-0.0558		0.0176	
	(0.0223)		(0.0281)		(0.0224)		(0.0264)		(0.0348)		(0.0342)	
Daughter 0-5		-0.0695***		0.0294		-0.0768***		0.0157		-0.0539		0.0232
		(0.0257)		(0.0283)		(0.0256)		(0.0268)		(0.0372)		(0.0343)
Daughter 6-10		-0.0330		0.0281		-0.0519*		0.0095		-0.0527		0.0025
		(0.0284)		(0.0342)		(0.0272)		(0.0314)		(0.0406)		(0.0427)
Daughter 11+		-0.00475		-0.00720		-0.0267		-0.0346		-0.0637		-0.0345
		(0.0279)		(0.0393)		(0.0275)		(0.0370)		(0.0495)		(0.0522)
Observations	39,736	39,736	39,736	39,736	44,654	44,654	44,654	44,654	17,984	17,984	17,984	17,984
R-squared	0.102	0.103	0.014	0.014	0.107	0.107	0.013	0.014	0.099	0.099	0.021	0.021
Individuals			9,467	9,467			10,539	10,539			2,630	2,630

Notes: Robust standard errors in parentheses (clustered by individual for pooled OLS estimates). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables in all columns: 4 dummies for number of total children, age, age squared, 2 education dummies, 5 marital status dummies, 8 employment status dummies, ln household income, wave dummies, region dummies. The regressor 'daughter' is shorthand for 'at least one daughter'. Age groups are based on the youngest daughter if there is more than one daughter. Sources: BHPS, UKHLS.

4.5.2 Selection into co-residence after divorce and attrition

As detailed in Section 4.3, when parents divorce, the resident parent will typically be observed as divorced while the non-resident parent will drop out of our estimation sample, i.e. there is attrition from the sample. Hence, potential selection problems at family dissolution are essentially problems of potentially non-random attrition in our analysis.

In Table 4.8, we again use the collapsed cross-sectional data set, to test for bias arising from attrition. Panel a shows that having a daughter in at least one interview wave is not associated with attrition from the estimation sample, that is, the probability of dropping out of the sample before the last wave. In panel b, we test for attrition bias in our results by performing a BGLW test. This test is described in Fitzgerald et al. (1998) and was first used by and named after Becketti et al. (1988). To do so, we estimate the effect of ever having daughters on initial attitudes to gender norms. By comparing results using the total estimation sample to results using the sample of individuals who do not drop out of the sample before the last interview wave (i.e. the non-attrition sample), we examine whether coefficients would be different if only the non-attrition sample was used. We find that ever having a daughter is generally unrelated to initial attitudes. P-values from tests of differences in coefficients between the two samples (columns 3 and 6) suggest that there are no significant differences in coefficients between the total and the non-attrition samples. This also holds when we look at the daughter dummy differentiated by age groups. Hence, we can conclude that our coefficients are unaffected by attrition.

As a final check for selection into co-residence after divorce, and related attrition, in Table 4.7 we re-estimate the main results for two additional subsamples: individuals who are never observed as divorced (columns 5 to 8), and individuals who are not dropped from the estimation sample before the last survey wave (columns 9 to 12). For both subsamples, results are very similar to the main results. The negative effect of parenting daughters (independent of age group) even becomes statistically significant at the 10 percent level with FEs (columns 7 and 11). In line with the

results from the BGLW test in Table 4.8, there is no indication that family separation through divorce and related disappearance from our estimation sample drives our results.

Table 4.8: Testing for attrition bias

Panel a: Does having daughters predict attrition?

	(1)	(2)	(3)	(4)
	Probability of dropping out of sample before last wave			
	Male		Female	
Ever daughter	0.0024	0.0108	0.0085	0.0170
	(0.0112)	(0.0119)	(0.0107)	(0.0112)
Total no. of children controls	no	yes	no	yes
Observations	5,073	5,073	6,332	6,332
R-squared	0.232	0.235	0.271	0.274

Panel b: BGLW test

	(1)	(2)	(3)	(4)	(5)	(6)
	Initial attitude: gender division of work					
	Total sample	Non-attrition sample	p-value	Total sample	Non-attrition sample	p-value
Ever daughter	-0.0184	0.0389	0.34			
	(0.0323)	(0.0672)				
Ever daughter x female	0.0404	-0.0418	0.27			
	(0.0421)	(0.0841)				
Female	-0.274***	-0.230***	0.48	-0.238***	-0.243***	0.93
	(0.0363)	(0.0714)		(0.0316)	(0.0662)	
Ever daughter (youngest 0 to 5)				0.0227	0.0227	1.00
				(0.0334)	(0.0718)	
Ever daughter (youngest 6 to 10)				-0.0675*	0.0162	0.29
				(0.0348)	(0.0854)	
Ever daughter (youngest $\geq$ 11)				-0.0020	0.0360	0.64
				(0.0328)	(0.0846)	
Ever daughter 0 to 5 x female				-0.0769*	-0.0002	0.34
				(0.0438)	(0.0918)	
Ever daughter 6 to 10 x female				0.0496	-0.0510	0.32
				(0.0463)	(0.110)	
Ever daughter 11 plus x female				0.0149	0.0124	0.98
				(0.0426)	(0.107)	
Total no. of children controls	yes	yes		yes	yes	
Observations	11,405	2,630		11,405	2,630	
R-squared	0.110	0.106		0.110	0.106	

Notes: Panel a: robust standard errors in parentheses. Panel b: standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Controls in all panels & columns: age, age square, 2 education dummies, ln HH income, 5 marital status dummies, 8 employment status dummies, wave and region fixed effects. Additional controls in panel b: dummies for number of total children. Sources: BHPS, UKHLS.

4.5.3 Further robustness checks

Table 4.A.3, presented in Appendix 4.A, checks the robustness of our results to an alternative dependent variable, which measures levels of agreement with the state-

ment that 'both the husband and wife should contribute to the household income'. While this variable relates less directly to attitudes towards the gender division of work, it still captures attitudes towards gender norms more generally. We interpret higher levels of agreement with the statement as more gender-equal and hence less traditional attitudes. Our main findings are reflected with this alternative outcome variable: parenting daughters makes men less traditional, the effect is strongest for fathers of school-age daughters, and there are no statistically significant effects for mothers that are robust to the introduction of individual FEs.[17] Finally, we find that the main results with the binarized dependent variable (see columns 4 and 8 of Tables 4.2 and 4.3) are robust to estimating logit and FE logit models (Table 4.A.4 in Appendix 4.A).[18]

4.6 Discussion and conclusion

Understanding the malleability of attitudes towards gender norms is important for tackling gender inequality at its roots. Against the backdrop that attitudes are shaped early in life, we show that parenting daughters decreases fathers' likelihood to agree with a traditional gender division of work while there is no robust effect on mothers. This result is in line with previous US findings (Shafer & Malhotra 2011) supporting the idea that having a daughter affects men and women differently. More importantly, we show that the effect on fathers' attitudes occurs when daughters are of school age, which is a novel finding. We carefully check that our results are not driven by unobserved individual heterogeneity, endogenous fertility stopping rules, reverse causality, or attrition from the estimation sample. Finally, our findings on attitudes are also reflected in behavioural changes concerning gender norms, for the

[17]However, in contrast to our main outcome variable, the pooled OLS estimates indicate that both men and women with pre-school daughters are more traditional compared to those without daughters, and that mothers of secondary school-age daughters are less traditional compared to those without daughters.

[18]We also conducted a placebo test in which we created a random variable of a 'fake' daughter to check that our results do not just pick up some other trend that occurs in people's lives around the time when they have school-age children. As expected, we found no statistically significant effect of the placebo variables on attitudes to the gender division of work.

subsample of individuals living with a partner.

We build on the few papers which have examined the effect of a child's sex on attitudes towards gender norms in several ways. Not only are we one of few studies to provide longitudinal evidence and the first study to show UK evidence and to cover recent years, but we also enrich the literature by showing that there is an age-specific effect of daughters on fathers' gender norm attitudes.

While we are unable to test underlying mechanisms, the differential effect of parenting a daughter on fathers and mothers together with the finding of an age-specific daughter effect on attitudes is consistent with theories of exposure as well as with identity theories. Consistent with these theories, both father and mother may incorporate their children's well-being into their own utility function. Through parenting, fathers of daughters may develop a better understanding of gender inequality issues that women and girls face, resulting in a significant shift in their attitudes towards gender norms. Conversely, mothers have already been exposed to situations of disadvantage first-hand, and as a consequence, parenting a daughter has a negligible effect on their attitudes towards gender norms, which are already less traditional than that of men.

The timing of exposure - when daughters are of school-age - is in line with research in psychology which suggests that children become aware of gender stereotypes and social pressures to conform to gender norms around this age (Bian et al. 2017, Lane et al. 2017). Hence, fathers are likely to gradually become aware of the gender norms affecting their daughters' actions after that age, prompting the change in their gender norm attitudes. Our findings also provide evidence for theories of intra-cohort change in attitudes. Attitudes towards gender norms seem to be malleable to experiences during adulthood such as parenting a daughter, thus suggesting that indirect exposure to disadvantage has the potential to change people's attitudes.

4.A Appendix tables

Table 4.A.1: Baseline results with full set of covariates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS				Fixed Effects			
	Ordinal dep. variable			binary	Ordinal dep. variable			binary
AL (at least) 1 daughter	-0.113***	-0.119***	-0.0930***	-0.0310***	-0.0547**	-0.0571**	-0.0415	-0.0102
	(0.0255)	(0.0249)	(0.0242)	(0.0115)	(0.0270)	(0.0271)	(0.0271)	(0.0140)
Female	-0.276***	-0.263***	-0.295***	-0.117***				
	(0.0235)	(0.0231)	(0.0223)	(0.0102)				
AL 1 daughter x female	0.0803***	0.0963***	0.0495*	0.0063	0.0919***	0.0905***	0.0626**	0.0091
	(0.0294)	(0.0290)	(0.0280)	(0.0130)	(0.0300)	(0.0300)	(0.0302)	(0.0156)
One child	0.336***	0.341***	0.121***	0.0475***	0.114***	0.113***	0.0677***	0.0282***
	(0.0206)	(0.0221)	(0.0223)	(0.0102)	(0.0187)	(0.0199)	(0.0204)	(0.0107)
2 children	0.422***	0.447***	0.214***	0.0916***	0.199***	0.197***	0.150***	0.0608***
	(0.0230)	(0.0262)	(0.0262)	(0.0122)	(0.0227)	(0.0261)	(0.0267)	(0.0140)
3 children	0.537***	0.563***	0.295***	0.128***	0.188***	0.190***	0.142***	0.0582***
	(0.0290)	(0.0323)	(0.0323)	(0.0149)	(0.0317)	(0.0365)	(0.0372)	(0.0194)
4 or more children	0.765***	0.792***	0.446***	0.175***	0.262***	0.267***	0.220***	0.109***
	(0.0439)	(0.0464)	(0.0450)	(0.0201)	(0.0533)	(0.0576)	(0.0583)	(0.0290)
Age		-0.0467***	-0.0241***	-0.0093***		0.0254*	0.0230*	0.0130*
		(0.0049)	(0.0052)	(0.0023)		(0.0135)	(0.0136)	(0.0070)
Age squared		0.0007***	0.0005***	0.0002***		-0.0001	-0.0000	-0.0000
		(0.0001)	(0.0001)	(0.0000)		(0.0001)	(0.0001)	(0.0000)
First degree			-0.281***	-0.0964***			0.0642**	0.0171
			(0.0229)	(0.0104)			(0.0314)	(0.0148)
Higher degree			-0.316***	-0.110***			0.0260	-0.0028
			(0.0420)	(0.0180)			(0.0554)	(0.0279)
Marital: living as couple			-0.0275	-0.0038			-0.0117	0.0053
			(0.0192)	(0.0089)			(0.0181)	(0.0091)
Marital: widowed/other			-0.0437	-0.0351			0.0576	0.0485
			(0.0731)	(0.0349)			(0.0743)	(0.0349)
Marital: divorced			-0.138***	-0.0489***			-0.0102	0.0127
			(0.0307)	(0.0146)			(0.0317)	(0.0164)
Marital: separated			-0.179***	-0.0696***			0.0019	-0.0046
			(0.0365)	(0.0169)			(0.0361)	(0.0184)
Marital: never married			-0.121***	-0.0270**			-0.0541**	-0.0008
			(0.0263)	(0.0116)			(0.0249)	(0.0122)
Empl.: employed			-0.150***	-0.0733***			-0.0282	-0.0175
			(0.0243)	(0.0118)			(0.0214)	(0.0111)
Empl.: unemployed			0.0960***	0.0337**			0.0541*	0.0274*
			(0.0367)	(0.0165)			(0.0312)	(0.0160)
Empl.: retired			-0.151**	-0.0699*			0.108*	0.0371
			(0.0769)	(0.0383)			(0.0634)	(0.0320)
Empl.: family care			0.235***	0.0946***			0.140***	0.0618***
			(0.0375)	(0.0177)			(0.0325)	(0.0167)
Empl.: FT student			0.258***	0.113***			0.115***	0.0485***
			(0.0321)	(0.0150)			(0.0271)	(0.0140)
Empl.: LT sick/disabled			-0.251***	-0.0867***			-0.0749**	-0.0228
			(0.0396)	(0.0176)			(0.0347)	(0.0172)
Empl.: maternity leave			0.132***	0.0615***			0.0841**	0.0431**
			(0.0469)	(0.0212)			(0.0417)	(0.0196)
Empl.: gov't training/other			0.0040	0.0191			0.0811	0.0241
			(0.0635)	(0.0302)			(0.0583)	(0.0302)
Ln household income			-0.128***	-0.0563***			-0.0025	-0.0044
			(0.0103)	(0.0047)			(0.0084)	(0.0042)
Constant	2.105***	2.875***	3.655***	0.918***	2.125***	1.551***	1.635***	-0.0204
	(0.0204)	(0.0974)	(0.132)	(0.0591)	(0.0122)	(0.361)	(0.369)	(0.187)
Wave and region FEs		yes	yes	yes		yes	yes	yes
Observations	48,822	48,822	48,822	48,822	48,822	48,822	48,822	48,822
R-squared	0.041	0.061	0.106	0.075	0.006	0.009	0.013	0.010
No. of individuals					11,405	11,405	11,405	11,405

Notes: Robust standard errors in parentheses (clustered by individual for columns (1) to (4)). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Sources: BHPS, UKHLS.

Table 4.A.2: Summary statistics and variable definitions

Name	Description	Male		Female	
		Mean	SD	Mean	SD
Dependent variables					
Attitude: gender division of work (ordinal)	A husband's job is to earn money; a wife's job is to look after the home and family. 1=strongly disagree, 2=disagree, 3= neither agree nor disagree, 4=agree, 5=strongly agree	2.39	0.99	2.18	1.00
Attitude: gender division of work (binarized)	A husband's job is to earn money; a wife's job is to look after the home and family. 0=strongly disagree/disagree, 1= neither agree nor disagree/ agree/ strongly agree	0.40		0.31	
Behaviour: Traditional gender division of work	Male subsample: 1=individual (self-)employed & partner not (self-)employed, 0=otherwise	0.24			
Key regressors					
At least (AL) one daughter	1=At least one daughter in the household, 0=otherwise	0.57		0.58	
AL 1 daughter (youngest 0 to 5)	1=At least one daughter in the HH, with the youngest aged 0 to 5; 0=otherwise	0.21		0.21	
AL 1 daughter (youngest 6 to 10)	1=At least one daughter in the HH, with the youngest aged 6 to 10; 0=otherwise	0.14		0.15	
AL 1 daughter (youngest 11 plus)	1=At least one daughter in the HH, with the youngest aged at least 11; 0=otherwise	0.22		0.23	
Covariates					
No children	1=no children in the HH, 0=otherwise	0.19		0.15	
One child	1=one child in the HH, 0=otherwise	0.25		0.28	
Two children	1=two children in the HH, 0=otherwise	0.38		0.38	
Three children	1=three children in the HH, 0=otherwise	0.14		0.14	
4 or more children	1=four children in the HH, 0=otherwise	0.04		0.05	
Number of children	Total number of children in the HH (values 0 to 9)	1.62	1.12	1.66	1.10
Age	Age in years	37.53	9.94	35.41	9.39
First degree	Educational level: 1=First degree (undergraduate), 0=otherwise	0.13		0.11	
Higher degree	Educational level: 1=Higher degree (postgraduate), 0=otherwise	0.04		0.03	
Married	Marital status: 1=married, 0=otherwise	0.74		0.62	
Living as couple	Marital status: 1=living as couple, 0=otherwise	0.16		0.15	
Widowed/other	Marital status: 1=widowed/other status, 0=otherwise	0.00		0.01	
Divorced	Marital status: 1=divorced, 0=otherwise	0.02		0.06	
Separated	Marital status: 1=separated, 0=otherwise	0.01		0.03	
Never married	Marital status: 1=never married, 0=otherwise	0.08		0.13	
Self-employed	Employment status: 1=self-employed, 0=otherwise	0.15		0.04	
In paid employment	Employment status: 1=in paid employment, 0=otherwise	0.73		0.62	
Unemployed	Employment status: 1=unemployed, 0=otherwise	0.06		0.03	
Retired	Employment status: 1=retired, 0=otherwise	0.01		0.00	
Family care	Employment status: 1=family care, 0=otherwise	0.00		0.06	
FT student	Employment status: 1=ft student, 0=otherwise	0.01		0.18	
Long-term sick/disabled	Empl. status: 1=long-term sick/disabled, 0=otherwise	0.02		0.03	
Maternity leave	Employment status: 1=maternity leave, 0=otherwise	0.03		0.03	
Gov't training scheme/other	Employment status: 1=government training scheme/ other, 0=otherwise	0.01		0.01	
Ln HH income	Natural logarithm of household income	7.83	0.69	7.72	0.73
Variables used in robustness checks					
Attitude: contribution to HH income	Both the husband and wife should contribute to the HH income. 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree	3.41	0.91	3.50	0.93
Only daughters (youngest 0 to 5)	1=Only daughters in the HH, with the youngest aged 0 to 5; 0=otherwise	0.11		0.11	
Only daughters (youngest 6 to 10)	1=Only daughters in the HH, with the youngest aged 6 to 10; 0=otherwise	0.04		0.05	
Only daughters (youngest 11 plus)	1=Only daughters in the HH, with the youngest aged at least 11; 0=otherwise	0.07		0.08	
First daughter (0 to 5)	1=Oldest child in HH is female & 0 to 5; 0=otherwise	0.10		0.10	
First daughter (6 to 10)	1=Oldest child in HH is female & 6 to 10; 0=otherwise	0.09		0.09	
First daughter (11 plus)	1=Oldest child in HH is female & at least 11; 0=otherwise	0.19		0.20	
AL 1 daughter (oldest 0 to 5)	1=At least one daughter in the HH, with oldest aged 0 to 5; 0=otherwise	0.17		0.16	
AL 1 daughter (oldest 6 to 10)	1=At least one daughter in the HH, with oldest aged 6 to 10; 0=otherwise	0.14		0.14	
AL 1 daughter (oldest 11 plus)	1=At least one daughter in the HH, with oldest aged at least 11; 0=otherwise	0.26		0.28	
Number of observations		20,851		27,971	
Number of individuals		5,073		6,332	

Sources: BHPS, UKHLS.

Table 4.A.3: Alternative dependent variable

	(1)	(2)	(3)	(4)
	Pooled OLS		Fixed Effects	
Dependent variable: Both husband & wife should contribute to HH income				
At least one daughter	0.0393*		0.0360	
	(0.0222)		(0.0285)	
Female	0.144***	0.137***		
	(0.0211)	(0.0212)		
At least one daughter x female	-0.0242		-0.0537*	
	(0.0258)		(0.0313)	
At least one daughter (youngest 0 to 5)		-0.0589**		0.0011
		(0.0253)		(0.0288)
At least one daughter (youngest 6 to 10)		0.0785***		0.133***
		(0.0270)		(0.0337)
At least one daughter (youngest 11 plus)		0.117***		0.179***
		(0.0267)		(0.0376)
Daughter 0 to 5 x female		0.0059		-0.0284
		(0.0296)		(0.0319)
Daughter 6 to 10 x female		-0.0622*		-0.0923**
		(0.0326)		(0.0384)
Daughter 11 plus x female		-0.0343		-0.123***
		(0.0318)		(0.0427)
Linear combination of estimates: effect for females				
At least one daughter	0.0152		-0.0178	
	(0.0195)		(0.0265)	
At least one daughter (youngest 0 to 5)		-0.0530**		-0.0273
		(0.0223)		(0.0267)
At least one daughter (youngest 6 to 10)		0.0163		0.0411
		(0.0238)		(0.0312)
At least one daughter (youngest 11 plus)		0.0827***		0.0563
		(0.0234)		(0.0355)
Observations	48,741	48,741	48,741	48,741
R-squared	0.070	0.072	0.032	0.033
Number of individuals			11,396	11,396

Notes: Robust standard errors in parentheses (clustered by individual for columns (1) to (2)). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables in all columns: 4 dummies for number of total children, age, age squared, 2 education dummies, 5 marital status dummies, 8 employment status dummies, ln household income, wave dummies, region dummies. Dependent variable: Level of agreement with the statement that husband and wife should both contribute to household income (1=strongly disagree, 5=strongly agree). Sources: BHPS, UKHLS.

Table 4.A.4: Logit and fixed effects logit models with binary dependent variable

	(1)	(2)	(3)	(4)
	Logit		Fixed Effects Logit	
	Binary dependent variable			
At least one daughter	-0.169***		-0.124	
	(0.0511)		(0.0966)	
At least one daughter x female	0.0772		0.159	
	(0.0618)		(0.107)	
Female	-0.587***	-0.592***		
	(0.0511)	(0.0513)		
At least one daughter (youngest 0 to 5)		-0.103*		-0.0719
		(0.0576)		(0.0987)
At least one daughter (youngest 6 to 10)		-0.242***		-0.259**
		(0.0637)		(0.115)
At least one daughter (youngest 11 plus)		-0.189***		-0.368***
		(0.0616)		(0.131)
Daughter 0 to 5 x female		-0.0662		0.112
		(0.0709)		(0.110)
Daughter 6 to 10 x female		0.140*		0.252*
		(0.0785)		(0.132)
Daughter 11 plus x female		0.169**		0.243*
		(0.0758)		(0.147)
Observations	48,822	48,822	26,306	26,306
Number of individuals			4,553	4,553

Notes: Standard errors in parentheses (clustered by individual for columns (1) to (2)). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables in all columns: 4 dummies for number of total children, age, age squared, 2 education dummies, 5 marital status dummies, 8 employment status dummies, ln household income, wave dummies, region dummies. Sources: BHPS, UKHLS.

Chapter 5

Robots and the gender pay gap in Europe[1]

Abstract

Could robotization make the gender pay gap worse? We provide the first large-scale evidence on the impact of industrial robots on the gender pay gap using data from 20 European countries. We show that robot adoption increases both male and female earnings but also increases the gender pay gap. Using an instrumental variable strategy, we find that a ten percent increase in robotization leads to a 1.8 percent increase in the gender pay gap. We rule out the possibility that our results are driven by mechanical changes in the sex composition of the workforce. Instead, our results are driven by countries with high initial levels of gender inequality and can be explained by the fact that men in medium- and high-skilled occupations disproportionately benefit from robotization, through a productivity effect.

[1]This chapter is written jointly with Cevat Giray Aksoy and Berkay Özcan, and a version of it is published as: Robots and the gender pay gap in Europe. European Economic Review, Vol. 134, article 103693, May 2021. An earlier working paper version is published in IZA Discussion Papers, No. 13482, Institute of Labor Economics (IZA), July 2020.

5.1 Introduction

Technological innovations are quickly shifting the frontier between tasks performed by humans and those performed by machines, transforming the world of work. Advances in robot technologies and the increased adoption of industrial robots in production processes have augmented interest in the impacts of robots on labor markets. Specific focus on robots is warranted because rapid robotization is ongoing. The annual sales volume of industrial robots increased by 114 percent in Europe since 2013 and is expected to continue double-digit growth (International Federation of Robotics 2018). However, despite recent examinations of the impact of robots on overall employment and earnings (Graetz & Michaels 2018, Acemoglu & Restrepo 2020), there has been little empirical research on how robot adoption might affect gender equality.

In this paper, we provide the first large-scale evidence on the impact of industrial robots on the gender pay gap in Europe, using data from 28 million workers across 20 European countries for the period between 2006 and 2014. Specifically, we examine how changes in the number of robots per worker between survey years (henceforth, 'robotization') affect the gender gap in the monthly earnings of workers in manufacturing and a few other sectors that employ robots.[2] We are also able to investigate the role of initial country conditions in terms of gender equality and to test underlying mechanisms of our results.

An industrial robot is defined as an 'automatically controlled, reprogrammable, multipurpose manipulator, programmable to perform tasks in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications' (International Federation of Robotics 2017). Industrial robots are mainly employed in the manufacturing sector to perform tasks such as assembling, painting and welding. We refer to the number of robots per 10,000 workers as 'robot density'.

[2]Specifically, we have 12 industries: eight manufacturing (manufacturing of automotive/transport, plastic/chemicals, metal, food/beverages, electrical/electronics, wood/paper, textiles, and other manufacturing branches) and four non-manufacturing industries (mining/quarrying, education/research/development, construction, utilities).

Europe is an important setting because the exposure of its workers to industrial robots in 2016 was 19 percent higher compared with workers in the USA (Chiacchio et al. 2018). At the same time, the average gender pay gap is proving rather immune to change and remains at around 15 percent (that is, women's gross hourly earnings are, on average, 14.8 percent below those of men), with some variation between countries (Eurostat 2018). Therefore, studying the impact of robotization on the gender pay gap in Europe is important as it has implications for the success of ongoing policy efforts to reduce the pay gap. Progress from policies to increase the number of women in the paid workforce and to increase women's pay to equal that of men may be removed if women are disadvantaged by the process of automation (Brussevich et al. 2018).

There are several ways in which we may expect robotization to affect the gender pay gap. On the one hand, robots perform physical tasks and replace 'brawn' skills, weakening the comparative advantage of low-skilled men compared to women (Rendall 2017). Similarly, low-skilled men are more likely to be employed in manual jobs with higher robotization risks, whereas women are thought to have a comparative advantage in services (Ngai & Petrongolo 2017, Muro et al. 2019). In line with these arguments, we may therefore expect robotization to decrease the gender pay gap. On the other hand, skilled male workers are more likely to benefit from robot-driven productivity increases. This is not only because men disproportionately occupy higher positions in the occupational hierarchy but also they are overrepresented in relevant STEM (science, technology, engineering, maths) occupations. For these reasons, we expect the effect of robotization to differ across skill-based occupational groups.

We find that, overall, robotization increases both male and female earnings and also increases the gender pay gap: a ten percent increase in robotization leads to a 1.8 percent increase in the (conditional) gender pay gap. The conditional pay gap is the pay gap after adjusting for a set of factors that may account for differences between men's and women's earnings. In our paper, these factors include

occupational category, industry, age group, country, year and firm size.[3]

Our results suggest that the underlying mechanism for our finding is that skilled men disproportionately benefit from robotization, through a productivity effect. In particular, we find that the increase in the gender pay gap due to robotization is driven by those in medium- and high-skilled occupations. Put differently, the underrepresentation of women in medium- and high-skilled occupations in specific industries accompanied by robotization exacerbates the gender pay gap. This is in line with recent research, which shows that firm-level adoption of robots coincides with increases in value added and productivity (Acemoglu et al. 2020) and increases wages of high-skilled workers relative to low-skilled workers while also increasing average wages of manufacturing workers (Barth et al. 2020). We further show that, in line with the findings of Freeman et al. (2020)[4], our results cannot be explained by changes in the sex composition of the workforce within industries, nor by inflows or outflows from the manufacturing sector.

We also find that our results are driven by countries in which initial overall gender inequality, measured by the Gender Gap Index (GGI) of the World Economic Forum, is high. Conversely, in countries where initial gender inequality is low, robotization does not have any statistically significant effect on the gender pay gap. Instead, it increases the earnings of all workers.

There is a risk of potential endogeneity of robotization to the gender pay gap. For example, some industries may be adopting robots in response to domestic shocks to industries, which may directly impact the gender pay gap (e.g. industry-specific minimum wage changes). To identify a causal effect, we therefore follow Graetz & Michaels (2018) and instrument robotization with an industry level replaceability index. In particular, our instrument specifies the fraction of each industry's hours worked in 1980 in the United States that was performed by occupations that became

[3]From a policy perspective, the conditional GPG is more important than the unconditional (overall) pay gap because it is related to 'equal pay' legislation in Europe.

[4]Freeman et al. (2020) find that degrees of automation are only weakly related to subsequent changes in occupational employment. The authors claim: 'within-occupation impacts of technology may offer a better path to projecting the future of work than forecasts of changing employment levels or occupational shares.' (p. 394).

replaceable by robots by 2012 (Graetz & Michaels 2018). The replaceability index strongly predicts the increase in robot intensity: as robot prices fell, industries with a higher initial replaceability increased their use of robots.

Our paper makes three contributions. First, our paper contributes to the growing literature on the labour market impacts of industrial robots by providing evidence on the impact of robotization on the gender pay gap in Europe. Existing research points to mixed impacts of robot adoption on labour markets in Europe. For example, Graetz & Michaels (2018) find that robotization increases both labor productivity and wages and has no effect on employment in 14 European and three non-European countries. Evidence from Germany suggests that robot adoption has no effect on total employment and also does not increase the risk of displacement for incumbent manufacturing workers. Using a local labor market approach, which exploits variation in robot exposure across commuting zones in the United States, Acemoglu & Restrepo (2020) show that industrial robot exposure reduces both employment and wages. Existing evidence therefore varies across contexts, with generally more positive effects in Europe compared to the United States. Our paper contributes to this growing literature by focusing on the gender pay gap – a crucial but neglected policy-relevant outcome.

Second, we contribute to the literature on the gendered labor market impacts of robotization. To the best of our knowledge, there are only two existing studies on the gendered impacts of industrial robots. They both exploit variation in robot exposure across commuting zones in the US. Their results indicate that robotization decreases both male and female earnings and also decreases the gender pay gap (Anelli et al. 2019, Ge & Zhou 2020). These findings contrast those from our paper, which is in line with the contrasting results across Europe and the US emerging from the research on the overall impact of robots on employment and wages (Graetz & Michaels 2018, Acemoglu & Restrepo 2020). There are also attempts to identify the gendered impacts of task automation (not just robotization) through relating data on task composition at work to occupation-level estimates of the probability of automation. For example, Brussevich et al. (2019) find that female workers are

at a significantly higher risk for displacement by automation than male workers, albeit with significant cross-country heterogeneity. This is because "female workers perform fewer tasks requiring analytical and interpersonal skills or physical labor, and more tasks that are routine, characterized by lack of job flexibility, little learning on the job, and greater repetitiveness" (Brussevich et al. 2018, p. 8). They also show that the probability of automation is lower for younger cohorts of women, and those in managerial positions.

Third, our paper also contributes to the broader literature on the determinants of the gender pay gap. An extensive literature has studied the factors that explain gender pay differences (see Kunze (2018) for a recent review). However, most research focuses on supply-side explanations, such as gender differences in human capital factors, psychological attributes, or occupations (Blau & Kahn 2017). There is much less evidence on how demand-side factors (such as automation) affect the pay gap (see reviews in Ngai & Petrongolo 2017, Petrongolo & Ronchi 2020). Studies that focus on computerization find that it contributed to the narrowing of the gender pay gap (Weinberg 2000, Black & Spitz-Oener 2010, Yamaguchi 2018). Differential changes in tasks can explain this finding: While women experienced a marked decline in routine tasks, men did not (Black & Spitz-Oener 2010). While white-collar workers directly work with computers, industrial robots are employed at the firm level. Therefore, the underlying mechanisms for the gendered impacts of robots are fundamentally different from those of computerization. We contribute to this literature by providing evidence on the impact of robotization, an important demand-side factor.

The rest of the paper is organized as follows: The next section provides background information on robotization trends in our sample of European countries. Section 5.3 describes the data, and Section 5.4 describes the empirical approach. Section 5.5 presents our results, and Section 5.6 discusses heterogeneity across countries and potential mechanisms. The final section concludes.

5.2 Background

Europe has seen tremendous growth in robotization over the sample period, both in absolute terms and as a percentage of the number of workers employed. The number of robots per 10,000 workers increased, on average, by 47 percent in our sample of 20 European countries between 2006 and 2014. However, Figure 5.1 shows that the level and growth of robot density vary substantially across countries. With almost 50 robots per 10,000 employees in 2014, Germany shows the highest robot density. On the other hand, Bulgaria, Latvia, and Lithuania have the lowest robot density in our sample, with less than one robot per 10,000 workers. Furthermore, Figure 5.1 shows that many countries have seen high growth in the number of robots per worker. For example, the Czech Republic saw rapid robotization, with robot density growing from 6 per 10,000 workers in 2006 to 23 per 10,000 workers in 2014.

Figure 5.2A shows that industrial robots are mainly deployed in the automotive and transport industry (about 390 robots per 10,000 workers in 2014), although they have also begun to be used more widely in the plastic, chemicals, metals as well as food and beverage sectors. Figure 5.2A highlights that the vast majority of industrial robots are employed in industries that are part of the manufacturing sector.

To understand whether there was a change in the sex composition of the workforce over the sample period, we present the share of female workers by industry and year in Figure 5.2B. The share of women is largest in the education/research/development (women accounted for 68 percent of all workers in the sector in 2014), the textile (63 percent), and food and beverages (47 percent) sectors. Women are least represented in the automotive and transportation, metal, construction, and mining and quarrying industries. Overall, within-industry sex composition changes have been minimal (2 percentage points or less) between 2006 and 2014. Even in industries in which sex composition changes have been largest, notably wood and paper (7 percentage points), electrical/electronics (5 percentage points), and automotive/transport sectors (4 percentage points), these are still relatively small.

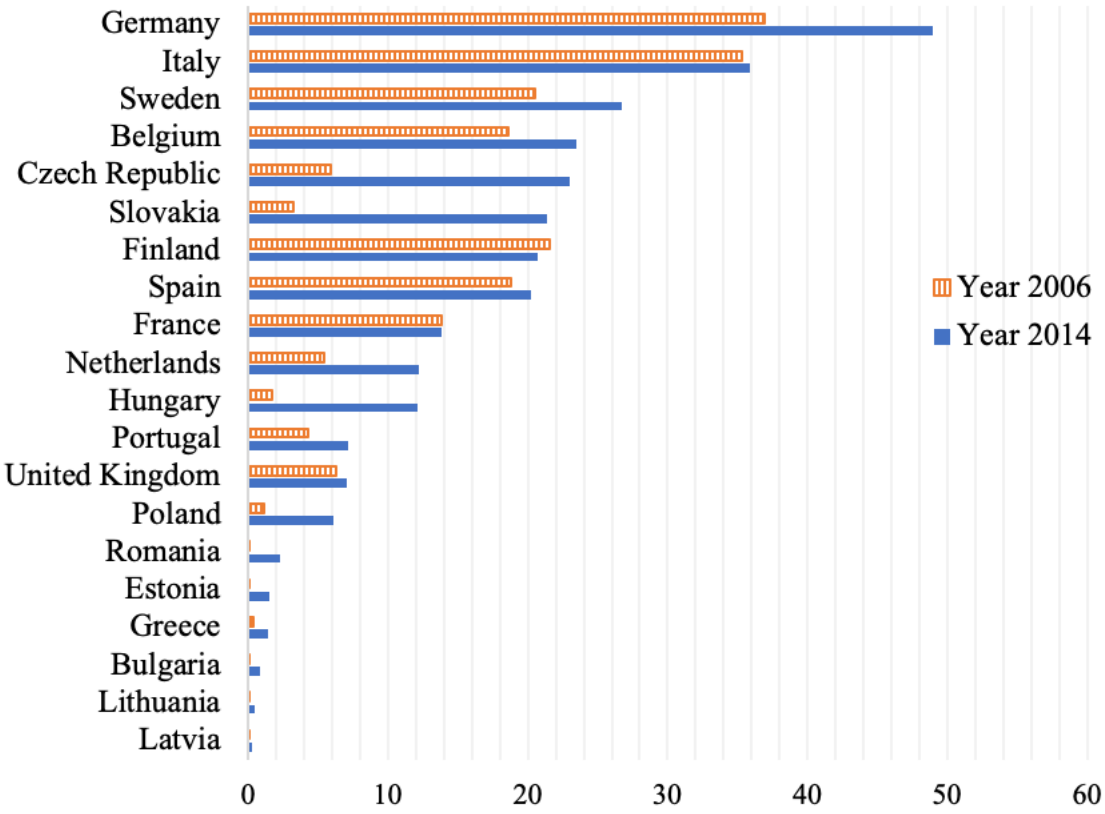

Figure 5.1: Industrial robots per 10,000 workers by country

Sources: IFR (2017), EU KLEMS, authors' calculations.

Figure 5.3 shows the gender gap in median monthly earnings in 2010 for the 20 countries included in our sample. For part-time workers, the equivalent full-time earnings are used. The size of the gender pay gap varies across economies: it ranges from 4 percent in Romania and Bulgaria to 18 percent in Germany and 19 percent in Estonia. Additional analysis suggests that there has been a downward trend in the gender pay gap since 2006 and the average pay gap stood at 11 percent in the manufacturing sector in 2014.

According to data from Eurostat, about two million enterprises were classified as working in manufacturing and nearly 34 million people were employed in the manufacturing sector in the EU-28, representing 15.4 percent of total employment in 2014. Although the role of manufacturing in Europe has declined in recent years (a

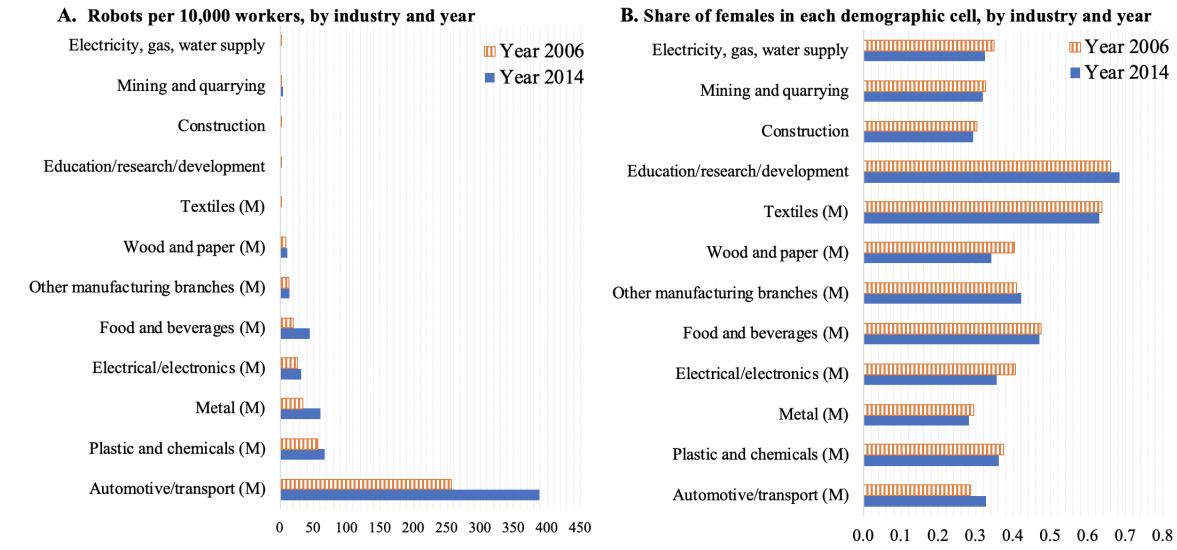

Figure 5.2: Robot density and share of females by industry

Sources: IFR, EU KLEMS, authors' calculations. (M) indicates manufacturing industry.

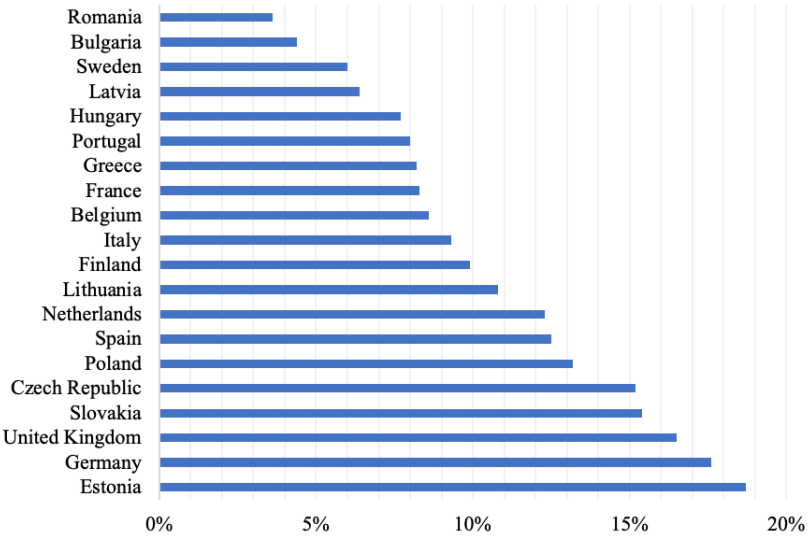

Figure 5.3: Gender gap in median monthly earnings 2010 by country

Source: EU-SES, authors' calculations. Notes: The gender gap in median monthly earnings is defined as in equation 5.2: the difference between median male earnings and median female earnings, divided by median male earnings. Earnings of part-time workers are adjusted to their full-time equivalents.

secular trend observed across advanced economies), the value of EU manufacturing production has increased from $1.835 trillion in 2004 to more than $2.229 trillion in 2014 in current prices (or by 11.4 percent in constant prices).[5] This means that, within the EU-28's non-financial business economy, the manufacturing sector is the largest contributor in terms of value added, and the second largest in terms of employment.[6]

Collectively, these findings suggest that: (i) the extent to which robots are used in industries varies significantly from country to country; (ii) the vast majority of robots are used in manufacturing (particularly in the automotive sectors), and within-industry sex composition changes have been limited over the sample period; (iii) despite some convergence, the gender pay gap remains large; (iv) despite the decline in recent years, manufacturing still provides a large share of employment in Europe. These findings provide additional motivation for our analysis, validating our predominant focus on manufacturing industries and highlighting the importance of studying heterogeneous effects across countries.

5.3 Data and descriptive statistics

5.3.1 Data

We use data from four independent sources: the International Federation of Robotics (IFR), the EU Structure of Earnings Survey (EU SES), the EU KLEMS database, and the EU Labour Force Survey (EU LFS).

IFR provides information on the number of robots by country, industry, and year (International Federation of Robotics 2017). It aims to capture the universe

[5]Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are available at: https://data.worldbank.org/indicator/NV.IND.MANF.CD?locations=EU (last accessed: 3/7/2020).

[6]See https://ec.europa.eu/eurostat/statistics-explained/pdfscache/10086.pdf, last accessed 3/7/2020.

of industrial robots, and it is based on consolidated data provided by nearly all industrial robot suppliers worldwide. Typical tasks performed by robots include welding, assembly, packaging, and picking. Dedicated industrial robots that are designed to perform only a single task are not included in the dataset.

The IFR dataset is provided at the country-industry level, with broad industry categories outside of manufacturing, more detailed categories within manufacturing, and a residual category 'other non-manufacturing', which comprises a large part of the service sector. It also provides information on the operational stock of robots based on annual robot deliveries with the assumption of the average service life of 12 years and full depreciation thereafter.

The second source of data is the EU-Structure of Earnings Survey (EU-SES) from Eurostat.[7] It covers the universe of enterprises with at least ten employees in all sectors except public administration and aims to provide harmonized data on labor market earnings from the EU Member States and Candidate Countries. EU-SES provides harmonized data on earnings, demographic and firm characteristics, and detailed industry classifications for 28 million individuals. The surveys have been collected every four years since 2002 and are based on a two-stage sample. In the first stage, a stratified random sample of local units is drawn, and in the second stage, a random sample of employees is taken within each of the selected local units.

EU-SES is well-suited for our purposes because it covers the workers who may be directly affected by robotization. Another advantage of the dataset is that the information collected relates to the wages paid to each job, ensuring that wages of the same person from additional jobs do not confound the analysis. Finally, it is the only dataset that provides harmonized information on labor market earnings and an industry classification at the 2-digit level of NACE (Statistical Classification of Economic Activities in the European Community) for a large sample of European countries. This feature is particularly important as it allows us to combine the dataset with the industrial robot data at the country and industry level.

We match EU-SES and IFR data for 20 countries, 12 industries, and the years

[7]The responsibility for all conclusions drawn from the data lies entirely with the authors.

2006, 2010, and 2014. The 12 industries comprise eight manufacturing (automotive/transport, plastic/chemicals, metal, food/beverages, electrical/electronics, wood/paper, textiles, and other manufacturing branches) and four non-manufacturing industries (mining/quarrying, education/research/development, construction, and utilities). Following prior research (Graetz & Michaels 2018), we exclude the residual category, other non-manufacturing, which comprises the majority of service sectors. The 20 countries comprise Belgium, Bulgaria, the Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and the United Kingdom.[8]

The level of analysis is at the 'demographic cell'. More specifically, we restrict our sample to those aged 20 to 59 with positive earnings information and a positive number of work hours. We then collapse the data at (i) country, (ii) industry, (iii) year, (iv) age group (20 to 29, 30 to 39, 40 to 49, 50 to 59); (v) broad occupational group (managers, professionals, associate professionals, clerical support workers, sales and service workers, craft and related trade workers, plant/machine operators and assemblers, and elementary occupations); and (vi) firm size (smaller and larger than 250 employees) level. We exclude the 'armed forces' and 'agricultural workers' occupational groups and any cells with missing values for any of the variables used in the analysis.

Our main sample consists of 24,215 demographic cells. On average, a demographic cell contains 342 observations. We drop demographic cells with fewer than ten respondents so that the smallest cell contains at least ten respondents, of which at least five are female and at least five are male. We use survey weights when collapsing the data to ensure averages are representative of the underlying target population.

Additional industry-level data on employment counts and information and communication technology (ICT) capital come from the EU KLEMS database.[9] We use data on total employment counts by country and industry to calculate the number

[8] In 2006, information for Germany, Romania, and Slovakia is not available and in 2014 information for Greece is missing.

[9] Downloaded from http://www.euklems.net (last accessed: 3/7/2020).

of robots per worker. Data on ICT capital are used as a control variable. ICT capital is measured by the real fixed capital stock in computing, communications, and computer software and databases equipment in 2010 prices, per 1,000 workers. We use Eurostat's EU-Labour Force Survey (EU-LFS) to understand compositional changes in the manufacturing sector. More specifically, we investigate movements into and out of manufacturing by demographic cells (such as age, sex, educational attainment, and skill level) using EU-LFS data from 2006, 2010, and 2014.[10] Data for our instrumental variables come from Graetz & Michaels (2018), and more details are provided in subsection 5.4.2.

Our key variable of interest is the inverse hyperbolic sine transformation (IHS) of the change in the number of robots per 10,000 workers between the current and last survey year, which we refer to simply as 'robotization':

$$\text{robotization} = IHS\left[\frac{\text{number of robots}_t}{\text{10,000 employees}_{2000}} - \frac{\text{number of robots}_{t-4}}{\text{10,000 employees}_{2000}}\right] \tag{5.1}$$

where t refers to a year. We use four-year changes as the EU-SES is a four-yearly survey. Robotization is calculated based on a constant base year, so that changes in robotization do not arise because of changes in the number of workers employed in an industry. Since the distribution of the change in robotization is highly skewed with a few large outliers, but also a substantial number of zeros and some negative values, the natural logarithm is an unsuitable transformation. We, therefore, follow common practice and apply the inverse hyperbolic sine transformation (Bellemare & Wichman 2020).

The main dependent variable is the gender gap in median monthly earnings in each cell, which we refer to as the gender pay gap. It is calculated as:

[10]The EU LFS (European Union Labour Force Survey) is the largest European household sample survey, currently including information from 35 European countries. Its main objective is to classify the working age population into employed, unemployed, and economically inactive. The responsibility for all conclusions drawn from the data lies entirely with the authors.

$$\text{Gender Pay Gap} = \frac{\text{median male earnings} - \text{median female earnings}}{\text{median male earnings}} \tag{5.2}$$

Median earnings are based on gross monthly earnings in the reference month.[11] In some countries such as Germany and the Netherlands, it is very common for women to work part-time, and therefore including full-time workers only would lead to a very selective sample. To avoid the possibility that the difference in men and women's monthly earnings can be attributed to the fact that women are more likely to work part-time, we adjust the earnings of part-time workers to their pro-rata full-time equivalents. The gender gap in median monthly earnings for all workers is larger than either the full-time or part-time pay gaps. This is because women are more likely than men to be in part-time employment, and part-time workers tend to earn less per hour than those working full-time. However, our results are robust to using alternative measures, namely (i) the gender gap in median monthly earnings without adjusting part-time earnings pro-rata; (ii) the gender gap in median hourly earnings. Again, we also find very similar point estimates (see Table 5.A.4 in Appendix 5.A).

To understand why robotization may affect the gender pay gap, in a first step we also study whether robotization increases or decreases male and female earnings. In line with the transformation of the robotization variable, we use the IHS transformation of male and female median monthly earnings in the analyses. Robustness checks using a logarithmic transformation of earnings return qualitatively similar results. All earnings are given in Euros and in constant 2015 prices.[12]

[11] We chose to use monthly earnings information over hourly earnings, given the differences across countries in regulating work hours. In a robustness check shown in Appendix 5.A, we show that using an hourly earnings measure does not substantially alter our results.

[12] We use exchange rates and CPI information from the Eurostat database (last accessed: 3/7/2020).

5.3.2 Descriptive statistics

Table 5.1 presents summary statistics of the variables used in the analysis, according to the skill-level of the occupation. Column 1 is high-skilled occupations; medium-skilled occupations are in Column 2; low-skilled occupations in Column 3; and the full sample in Column 4. The gender gap in median monthly earnings in the full sample is 11 percent. The median monthly gross male earnings are EUR 1,781, and female earnings are EUR 1,559. The mean robotization (that is, the change in robots per 10,000 employees between survey years) is 9.6. The share of women employed across the industries studied is 44 percent, which is consistent with the predominant focus on manufacturing industries in our paper.

The gender pay gap is 10 percent among individuals who work in high-skilled occupations, and 11 (13) percent among individuals who work in the medium (low)-skilled occupations. Both men and women also earn substantially more in high-skilled occupations (relative to medium- and low-skilled occupation groups). There are other notable differences: workers in high-skilled occupations are less likely to be exposed to robotization, more likely to be men, more likely to be in full-time work, and more likely to work in education, research and development, and construction sectors. There are no large differences when it comes to working for a large firm (that is, 250 workers or above).

5.4 Empirical strategy

5.4.1 OLS estimation

To assess the relationship between robotization and the gender pay gap, we start by estimating a series of OLS models which take the form:

$$\text{GPG}_{cid} = \beta_0 + \beta_1 \text{robotization}_{ci} + \beta_2 \text{controls}_{cid} + \delta + \theta + u_{cid} \tag{5.3}$$

where GPG_{cid} is the gender pay gap in country c, industry i, and demographic

Table 5.1: Summary Statistics

	High-skilled occupations		Medium-skilled occupations		Low-skilled occupations		Total	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Gender pay gap (monthly median earnings)	0.1	0	0.11	0	0.13	0	0.11	0
IHS male median monthly earnings	8.13	0.01	7.65	0.01	7.52	0.01	7.83	0.01
IHS female median monthly earnings	8.01	0.01	7.52	0.01	7.37	0.01	7.69	0.01
Female median monthly gross earnings (EUR)	2,049	19	1,265	13	1,087	13	1,559	11
Male median monthly gross earnings (EUR)	2,312	22	1,453	15	1,281	15	1,781	12
Overall median monthly earnings (EUR)	2,211	21	1,358	14	1,212	15	1,689	11
IHS of change in robotization	0.97	0.02	1.1	0.02	1.25	0.03	1.08	0.01
Change in robotization (per 10,000 workers)	8.5	0.47	9.87	0.57	11.19	0.71	9.6	0.32
Share of females	0.41	0	0.51	0	0.4	0.01	0.44	0
Change in share of females	0.01	0	-0.01	0	0	0	0	0
Gender gap in monthly hours paid	0.03	0	0.04	0	0.06	0	0.04	0
Share of full-time workers	0.9	0	0.87	0	0.88	0	0.88	0
IHS of change in ICT density	0.9	0.02	0.94	0.02	0.97	0.03	0.93	0.01
Dummy firm size > 250	0.48		0.47		0.46		0.47	
Age 20 to 29	0.2		0.22		0.21		0.21	
Age 30 to 39	0.27		0.26		0.24		0.26	
Age 40 to 49	0.27		0.27		0.28		0.27	
Age 50 to 59	0.25		0.26		0.28		0.26	
Industry: food and beverages (manuf.)	0.08		0.11		0.12		0.1	
Industry: textiles (manufacturing)	0.04		0.06		0.07		0.05	
Industry: wood and paper (manufacturing)	0.04		0.04		0.05		0.04	
Industry: plastic and chemicals (manuf.)	0.1		0.1		0.12		0.1	
Industry: metal (manufacturing)	0.12		0.14		0.15		0.13	
Industry: electrical/electronics (manuf.)	0.06		0.06		0.08		0.07	
Industry: automotive/transport (manuf.)	0.04		0.05		0.05		0.05	
Industry: other manufacturing (manuf.)	0.02		0.03		0.04		0.03	
Industry: mining and quarrying	0.01		0.01		0.01		0.01	
Industry: electricity, gas, water supply	0.05		0.04		0.05		0.05	
Industry: construction	0.16		0.14		0.1		0.14	
Industry: education, research, development	0.27		0.23		0.17		0.23	
Elementary occupations	0		0		0.57		0.14	
Managers	0.27		0		0		0.11	
Professionals	0.35		0		0		0.15	
Technicians & associate professionals	0.38		0		0		0.16	
Clerical support workers	0		0.44		0		0.15	
Service & sales workers	0		0.24		0		0.08	
Craft & related trade workers	0		0.32		0		0.11	
Plant & machine operators, assemblers	0		0		0.43		0.1	

Notes: Within-country industry employment shares used as survey weights. Sample size is 24,215 and average number of observations within a demographic cell is 342. Sources: EU-SES, IFR, EU KLEMS.

cell d, as defined in equation 5.2. Robotization_{ci} (that is, the change in the number of robots per 10,000 workers) is our main parameter of interest as defined in equation 5.1 and captures the effect of robotization on our gender pay gap measure.

In our fully saturated specification, we control for three age groups, seven occupational groups, sex composition (the share of females and the change in share of females between last and current survey year), labor market factors (share of full-time workers and a dummy variable for a firm size greater than 250 employees), as well as our measure of changes in information and communication technology (ICT) capital.

To account for factors that vary systematically across countries or over time, such as macroeconomic conditions or gender equality policies, we include a full set of country and year fixed effects.[13] The country dummies, δ, control for any time-invariant difference in unobserved factors that vary cross-nationally. Year dummies, θ, capture the impact of shocks that affect all countries simultaneously. We use robust standard errors, two-way clustered by country and industry, and adjusted for cases with few clusters. All regressions are weighted by within-country industry employment shares, giving more weight to larger industries within each country while giving equal weight to each country independent of population size.

Alongside the regression coefficients, we report elasticities for the models using the inverse hyperbolic sine transformation on the independent variable to ease interpretation. The elasticities are calculated from the regression coefficients following Bellemare & Wichman (2020). The formula used for regressions with the gender pay gap as a dependent variable is $\hat{\xi}_{yx} = \frac{\hat{\beta}}{y}\frac{x}{\sqrt{x^2+1}}$; and the formula used for regressions with the IHS of median earnings as dependent variable is $\hat{\xi}_{yx} = \hat{\beta} \cdot \frac{\sqrt{y^2+1}}{y} \cdot \frac{x}{\sqrt{x^2+1}}$.

5.4.2 Instrumental variable estimation

To identify the causal effects of robotization on the gender pay gap, we need to address the issues of omitted variables bias and reverse causality. Shocks to relative

[13] We cannot include industry fixed effects since our robotization variable is varying at the industry level.

female labor demand in an industry, such as industry-specific policies on gender-equal pay, may affect firms' decision making on whether to adopt robots. Further, firms may adopt robots in response to larger shocks to specific industries, which may also directly impact the gender pay gap.

To account for these possibilities, we use an instrumental variables strategy following Graetz & Michaels (2018). The first instrument, which we call 'replaceable hours', measures the share of each industry's hours worked in 1980 (that is, before robotization takes place) that were performed by occupations that were later susceptible to replacement by robots. This industry-level measure takes advantage of two key facts. First, robots perform a specific and limited set of tasks, such as welding, painting, and assembling. Second, each industry differs in the extent to which these tasks are performed. The data on our instrumental variable comes from Graetz & Michaels (2018). It is constructed using data on robot applications from the IFR, and US Census occupational classifications and distribution of hours worked by occupation and industry. If an occupation's title from the 2000 Census three-digit occupational classification contains at least one of the IFR application categories such as welding, painting, etc., it is labeled as replaceable.

The rationale for using this instrument is based on the assumption that firms employ robots when it is more profitable than employing workers. This is the case when the share of tasks in an industry that can be performed by robots exceeds a certain threshold (Graetz & Michaels 2018). Therefore, the instrument filters out robot adoption due to demand-side industry shocks. Instead, it only captures robot adoptions that are driven by technological advances in robots. Within this context, identification is achieved by an exclusion restriction that the replaceability measure should affect the gender pay gap only through robot adoption.

The validity of this instrument is strengthened by the findings in Freeman et al. (2020), who show that occupational attributes, such as 'replaceable tasks' have little predictive power for employment changes. To the extent that robotization affects pay gaps, our instrument ensures that this is consequent on the automation itself rather than compositional changes also associated with differences in pay between

men and women. While they do not fully address all possible endogeneity concerns, the instrumental variable analyses provide us with an additional check and help support our findings from our OLS estimations.

We also combine our 'replaceable hours' instrument with a second instrument, again following Graetz & Michaels (2018), called 'robotic arms'. It measures the extent to which industries employed occupations that required reaching and handling tasks, compared to other tasks in 1980, prior to robot adoption. This instrument takes advantage of the fact that robotic arms are a widespread and supply-side characteristic of robots. We use this instrument together with replaceable hours and also separately as an additional check reported in Appendix 5.A. The results using this instrument point in the same direction as the findings from the OLS estimation and 'replaceable hours' instrument.

5.5 Results

5.5.1 Main findings from OLS and IV estimations

Table 5.2 presents the main OLS results on the relationship between the gender pay gap and robotization. We report five model specifications: the baseline specification with no controls (column 1); Column 2 adds country and year fixed effects, Column 3 adds demographic (three age group and seven occupational group dummies) and job controls (share of full-time workers and a dummy indicating firm size larger than 250), Column 4 adds sex composition controls (share of females and change in share of females), and Column 5 adds a control variable for changes in ICT capital to ensure that changes in other technologies are not driving our results.

Without controls, we find that higher robotization is associated with a higher gender pay gap: our elasticity estimate suggests that a ten percent increase in robotization is associated with a 0.68 percent increase in the gender pay gap. After adding various controls (Columns 2 to 5), the coefficient size decreases to 0.004 with an elasticity of 0.035.

Table 5.2: Effect of robotization on gender gap in monthly earnings, OLS

Dependent variable	Gender pay gap				
	(1)	(2)	(3)	(4)	(5)
Robotization	0.007***	0.006*	0.004*	0.004**	0.004**
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Elasticity	0.068	0.054	0.035	0.035	0.035
Observations	24,215	24,215	24,215	24,215	24,215
Country fixed effects	No	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes	Yes
Job controls	No	No	Yes	Yes	Yes
Sex composition	No	No	No	Yes	Yes
ICT capital	No	No	No	No	Yes

Notes: The table reports results from OLS regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). All regressions include a constant. Demographic controls include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy variable indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital is the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

These results suggest that robotization and the gender pay gap are positively associated. But to address potential endogeneity, we turn to our IV model, and results are presented in Table 5.3. Panels A and B report first- and second-stage results from the replaceable hours instrument, respectively, and Panels C and D show results from the combined instrument of replaceable hours and robotic arms. The coefficients from the first stage regressions of the replaceable hours instrument in Panel A show that replaceable hours strongly predict robotization. In Panel B, we find that the first-stage F-statistic is between 16 and 20 in all specifications, indicating that the replaceability measure is a strong instrument. Our fully saturated specification in column 5 suggests that a 10 percent increase in robotization leads to a 1.8 percent increase in the gender pay gap. The average gender pay gap in our sample is 11 percent.

Panels C and D show the first- and second-stage estimates with two instrumental variables. We find that robotic arms do not predict robotization. The first-stage F-

Table 5.3: Effect of robotization on gender gap in monthly earnings, IV

	(1)	(2)	(3)	(4)	(5)
Panel A: IV replaceable hours 1st stage – outcome: robotization					
Replaceable hours	5.879***	5.601***	5.522***	5.389***	5.363***
	(1.391)	(1.260)	(1.287)	(1.336)	(1.326)
Panel B: IV replaceable hours 2nd stage – outcome: gender pay gap					
Robotization	0.023***	0.026**	0.018*	0.019*	0.019*
	(0.007)	(0.010)	(0.010)	(0.011)	(0.011)
Elasticity	0.208	0.238	0.169	0.175	0.177
First stage F-stat	17.87	19.75	18.41	16.27	16.37
Panel C: IV replaceable hours and robotic arms 1st stage – outcome: robotization					
Robotic arms	-6.884	-5.791	-5.898	-5.909	-6.100
	(6.510)	(5.537)	(5.478)	(5.673)	(5.616)
Replaceable hours	7.754***	7.215***	7.285***	7.291***	7.315***
	(2.190)	(1.853)	(1.907)	(2.020)	(1.997)
Panel D: IV replaceable hours and robotic arms 2nd stage – outcome: gender pay gap					
Robotization	0.023***	0.026***	0.019**	0.021*	0.021*
	(0.007)	(0.010)	(0.010)	(0.011)	(0.011)
Elasticity	0.213	0.240	0.177	0.189	0.191
First stage F-stat	9.147	10.73	9.869	9.189	9.352
Observations	24,215	24,215	24,215	24,215	24,215
Country fixed effects	No	Yes	Yes	Yes	Yes
Year fixed effect	No	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes	Yes
Job controls	No	No	Yes	Yes	Yes
Sex composition	No	No	No	Yes	Yes
ICT capital	No	No	No	No	Yes

Notes: The table reports results from IV regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic controls include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

statistic is around 7 in all models and the second-stage coefficients are very similar to those using the replaceable hours instrument only (Panel D): a ten percent increase in robotization leads to a 1.9 percent increase in the gender pay gap.

We also estimate results using the robotic arms instrument only, which are reported in Table 5.A.1 of Appendix 5.A. The coefficients are slightly smaller with larger standard errors but remain positive in sign. This is consistent both with our OLS estimates and with our replaceable hours instrument. Given the lack of predictive power of the robotic arms instrument, we focus solely on the replaceable hours instrument for the rest of the paper.

Our estimates for IV are larger than the OLS ones. This is in line with attenuation bias; that is, in the presence of omitted variables there could be a tendency to underestimate the impact of robotization on the gender pay gap.

While these results indicate that women lose out compared to men due to the adoption of robots, it is also important to understand whether this is driven by rising male or falling female earnings. Therefore, in Table 5.4, we present the effect of robotization on median male earnings (columns 1 and 2) and median female earnings (columns 3 and 4). In line with the robotization measure, we use the inverse hyperbolic sine transformation (IHS) of earnings as a dependent variable. Panel A shows OLS estimates and Panel B coefficients from the IV model, using the replaceability measure as an instrument for robotization.

When controlling for country and year fixed effects in column 1, OLS estimates in Panel A show a positive association between changes in robotization and male earnings. The coefficients remain similar when adding the full set of controls in column 2. Turning to female earnings, we can see that they are also positively associated with robotization. However, the size of coefficients is slightly smaller compared to those from the male earnings regressions. The coefficients from the IV model in Panel B remain positive but the coefficient on robotization is only significant for the full specification with male earnings as an outcome variable (Panel B, column 2). These results suggest that the increase in the gender pay gap due to robotization is driven by the larger positive effect on male earnings, compared to

Table 5.4: Effect of robotization on male and female earnings, OLS and IV

Outcome	Male earnings		Female earnings	
	(1)	(2)	(3)	(4)
	Panel A: OLS			
Robotization	0.019**	0.015***	0.012**	0.011**
	(0.008)	(0.005)	(0.006)	(0.004)
Elasticity	0.019	0.015	0.012	0.011
	Panel B. IV replaceable hours			
Robotization	0.046	0.047*	0.015	0.023
	(0.034)	(0.028)	(0.026)	(0.021)
Elasticity	0.046	0.046	0.015	0.023
First stage F-stat	19.75	16.37	19.75	16.37
Observations	24,215	24,215	24,215	24,215
Country fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	No	Yes
Job controls	No	Yes	No	Yes
Sex composition	No	Yes	No	Yes
ICT capital	No	Yes	No	Yes

Notes: The table reports results from OLS and IV regressions of the IHS (inverse hyperbolic sine transformation) of male (columns 1 and 2) and female (columns 3 and 4) earnings on the robotization (that is, IHS transformation of changes in number of robots per 10,000 workers). All regressions include a constant. Demographic controls include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy variable indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

female earnings.

5.5.2 Robustness checks and alternative specifications

We conduct a range of checks to ensure the robustness of our results, and the tables are included in Appendix 5.A. Our definition of a demographic cell distinguishes by skill-based occupational groups. This is necessary to be able to test heterogeneous effects across occupational hierarchies. However, we show that the positive relationship between robotization and the gender gap in earnings remains (and even becomes stronger) when we use an alternative demographic cell definition that does not distinguish across occupational groups (Table 5.A.2). This suggests that our

findings are robust to a demographic cell definition in which movements between occupations due to robotization cease to be relevant and cells contain information from individuals with more heterogenous skill levels.

Next, we show that our results are robust to the exclusion of Germany from the sample, as well as to the exclusion of the automotive and transport industry (Table 5.A.3). This alleviates concerns that our results are driven by the country or industry with the highest robotization. We adjust part-time earnings to pro-rata full-time earnings since part-time work for women is common in a few European countries. We show that our results are robust to gender pay gap definitions that are based on alternative earnings measures, (i) the gender gap in median monthly earnings without adjusting part-time earnings pro-rata, and (ii) the gender gap in median hourly earnings (Table 5.A.4). We also show that our results are robust to using the natural logarithm of robotization, instead of using an IHS transformation (Table 5.A.5). Finally, we report bootstrapped standard errors and find that the results do not change substantially (Table 5.A.6).

In Table 5.4, we showed that the increase in the gender pay gap due to robotization is driven by the fact that male earnings increase more strongly than female ones. We show that the positive association between robotization and (male and female) earnings holds across the earnings distribution by conducting quantile regressions at different percentiles of the distribution of median earnings of each demographic cell (Table 5.A.7).

5.6 Country heterogeneity and mechanisms

5.6.1 Heterogeneity across countries

The sample of countries included in our analysis differs in terms of each country's gender equality. If initial levels of gender inequality are high, this indicates that a country's institutions and policies are weaker with respect to fostering gender equality. It is therefore possible that the impact of robotization on an increased gender

pay gap could be driven by countries with high initial levels of gender inequality. To test this, we use the Gender Gap Index (GGI) of the World Economic Forum, which ranks countries' performance in economic, educational, health, and political dimensions of gender equality (see Hausmann et al. (2006)). We split our sample into two groups: the top ten countries with a high GGI score, hence higher levels of gender equality, and the bottom ten countries with a low GGI score, that is, lower levels of gender equality. The countries with high gender equality levels are Belgium, Germany, Estonia, Spain, Finland, Lithuania, Latvia, the Netherlands, Sweden, UK. Low GGI countries include Bulgaria, Czech Republic, France, Greece, Hungary, Italy, Poland, Portugal, Romania, and Slovakia.[14]

Results presented in Table 5.5 indicate that our main findings are mostly driven by countries with low levels of initial gender equality. This suggests that robotization exacerbates existing inequalities in these countries. On the other hand, robotization has no effect on the gender pay gap in countries with high initial gender equality.[15] We also performed additional analyses in which we split the countries into Eastern and Western European subsamples. We find that robotization increases the gender pay gap to a similar extent in both groups (see Appendix 5.A, Table 5.A.8). This suggests that initial gender equality per se, rather than regional grouping, mediates the impact of robotization on the gender pay gap.

Our sample of countries also varies in terms of the robotization experienced over the study period. Countries that have experienced high levels of robotization are not the same countries that have always enjoyed a high robot density. We therefore study results across levels of initial gender equality for the subsample of the ten countries that have had the highest changes in robots per worker over the study period (Table 5.6). We find that our main results are driven by countries with low overall gender equality but which experienced high robotization (Columns 4 and 6), such as the Czech Republic, Hungary, Italy, Poland, and Slovakia. With the

[14]The GGI scores are shown in Appendix 5.A, Table 5.A.9.

[15]We also tried to classify the 20 countries into 4 groups based on their GGI ranking, and the take-away remains the same. Robotization increases the gender pay gap among the two country groups with the lowest GGI rankings but has no effect on the two groups with higher GGI rankings.

Table 5.5: Heterogeneity by Gender Gap Index scores

Subsample	High GGI score (Higher gender equality)	Low GGI score (Lower gender equality)
	(1)	(2)
Panel A: OLS – outcome: gender pay gap		
Robotization	0.001	0.006**
	(0.001)	(0.003)
Panel B: IV replaceable hours – outcome: gender pay gap		
Robotization	0.006	0.027**
	(0.010)	(0.012)
First stage F-stat	8.57	16.62
Observations	10,401	13,814
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Demographic controls	Yes	Yes
Job controls	Yes	Yes
Sex composition	Yes	Yes
ICT capital	Yes	Yes

Notes: The World Economic Forum (WEF) Gender Gap Index (by Hausmann et al., 2006) ranks countries' performance in economic, educational, health, and political dimensions of gender equality. High GGI countries include Belgium, Germany, Estonia, Spain, Finland, Lithuania, Latvia, the Netherlands, Sweden, UK. Low GGI countries include Bulgaria, Czech Republic, France, Greece, Hungary, Italy, Poland, Portugal, Romania, and Slovakia. The table reports results from OLS and IV regressions of the gender gap in median monthly earnings in Panels A1 and A2, median male earnings in Panels B1 and B2, and median female earnings in Panels C1 and C2 on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, World Economic Forum Gender Gap Index by Hausmann et al. (2006), own calculations.

exception of Italy, these are a subset of the Eastern European countries. The size of the coefficient for this group of countries is almost identical to the effect we found for the full sample of countries (Table 5.3, Column 5). In line with results presented in Table 5.5, robotization had no effect on the gender pay gap in countries with high overall gender equality (and high robotization), which includes Belgium, Germany, the Netherlands, Spain, and Sweden.[16]

[16]Germany has a unique position, with high levels of robotization and robot density as well as a dominant automotive/transport industry. Dauth et al. (2018) analyzed German data to investigate how robotization affected the outcomes of individual workers, but did not examine potential gendered impacts. We therefore reran our models just on the German sample to check the consistency of our results with theirs. Our findings are compatible: we find both male and female earnings in Germany modestly increased due to robotization in comparable amounts, keeping the gender pay gap relatively unchanged (not shown here but available upon request). As discussed

Table 5.6: Heterogeneity by Gender Gap Index for high robotization countries

Sample	High robotization and high gender gap equality			High robotization and low gender equality		
Outcomes	Gender gap in earnings	IHS male earnings	IHS female earnings	Gender gap in earnings	IHS male earnings	IHS female earnings
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: OLS			
IHS Robotization	0.002	0.008**	0.006*	0.005*	0.021***	0.015**
	(0.002)	(0.004)	(0.004)	(0.003)	(0.008)	(0.006)
			Panel B: IV replaceable hours			
IHS Robotization	0.005	0.023	0.018*	0.019**	0.040*	0.017
	(0.005)	(0.014)	(0.011)	(0.009)	(0.023)	(0.019)
1st stage F-stat	21.07	21.07	21.07	18.57	18.57	18.57
Observations	5,428	5,428	5,428	8,219	8,219	8,219
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Demogr. controls	Yes	Yes	Yes	Yes	Yes	Yes
Job controls	Yes	Yes	Yes	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Countries with high robotization and high GGI include Belgium, Germany, Spain, the Netherlands, and Sweden. Countries with high robotization and low GGI include the Czech Republic, Hungary, Italy, Poland, and Slovakia. The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

In sum, robotization exacerbated the gender pay gap in countries in which overall gender inequality was already high. These are predominantly Eastern European countries (but do not include all Eastern European countries in our sample). In contrast, in countries where initial gender inequality was low, robotization did not increase the gender pay gap. These results also hold when focusing only on the countries that experienced higher increases in robotization.

in the robustness checks section, we also show that our results are not affected by exclusion or inclusion of Germany nor of automotive industry.

5.6.2 Potential mechanisms

In this section, we analyze two potential mechanisms underlying the observed relationship between robotization and the gender pay gap. First, robotization may lead to differential earnings increases at different parts of the occupational ranking, where men and women are disproportionately present (or they benefit differentially from earnings increases). Second, robotization may lead to compositional changes at the industry level, and employment levels of men and women are affected differentially leading to an increase in the gender pay gap.

To test the first mechanism, we explore heterogeneity by skill-based occupational groups. The results presented in Table 5.7 show that robotization leads to an increase in the gender pay gap for medium- and high-skilled occupations. In contrast, there is no effect of robotization among those in low-skilled occupations.

Table 5.7: Gender pay gap by skill-based occupational groups

Subsample	Low-skilled	Medium-skilled	High-skilled
	(1)	(2)	(3)
Panel A: OLS – outcome: gender pay gap			
Robotization	0.001	0.008**	0.002**
	(0.003)	(0.003)	(0.001)
Panel B: IV replaceable hours – outcome: gender pay gap			
Robotization	-0.001	0.037***	0.014*
	(0.013)	(0.013)	(0.008)
First stage F-stat	14.77	19.15	16.09
Observations	6,399	7,991	9,825
Country fixed effects	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes
Job controls	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes

Notes: The table reports results from OLS and IV regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Next, we explore whether the heterogeneous results across occupational ranking can be explained by the fact that men higher in the occupational hierarchy disproportionately benefit from robotization, through productivity effects. Skilled male workers may be more likely to benefit from robot-driven productivity increases. This is because men disproportionately occupy higher positions in the occupational hierarchy. Moreover, they are overrepresented in skilled, high-paid STEM occupations where we would most likely expect to see benefits from robot-driven productivity increases for workers.

Building on results from Table 5.6, which demonstrated the importance of the initial gender inequality situation of the country, we focus on the subsample of countries with high initial gender inequality and high robotization. The results in Table 5.8 confirm that robotization is associated with statistically significant earnings premia for male workers in medium- and high-skilled occupations. This is in line with the observation that women are under-represented in high-paying occupations and with Goldin (2014), who shows that within-occupation wage differentials actually account for a larger proportion of the gender wage gap than between-occupation wage differentials. On the other hand, the results also show that robotization positively impacts female earnings only for those in low-skilled occupations. Our results suggest that the underlying mechanism for the impact of robotization on an increased gender pay gap is that skilled men disproportionately benefit from robotization, through a productivity effect.[17]

[17]For completeness, results by skill-based occupational groups for countries with high robotization and *high* initial gender equality are included in Table 5.A.10 in Appendix 5.A.

Table 5.8: Heterogeneity by skill-based occupational groups for countries with high robotization and low levels of gender equality

Occupational group	Low-skilled			Medium-skilled			High-skilled		
Outcomes	Gender gap in earnings	IHS male earnings	IHS female earnings	Gender gap in earnings	IHS male earnings	IHS female earnings	Gender gap in earnings	IHS male earnings	IHS female earnings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Panel A: OLS					
IHS Robotization	0.002	0.017***	0.016***	0.011*	0.025***	0.012**	0.005***	0.016*	0.011
	(0.002)	(0.006)	(0.006)	(0.006)	(0.010)	(0.006)	(0.001)	(0.009)	(0.009)
				Panel B: IV replaceable hours					
IHS Robotization	-0.002	0.033*	0.037**	0.037***	0.052*	0.009	0.022**	0.024	-0.005
	(0.009)	(0.018)	(0.014)	(0.011)	(0.028)	(0.022)	(0.010)	(0.021)	(0.025)
1st stage F-stat	23.47	23.47	23.47	22.20	22.20	22.20	17.60	17.60	17.60
Observations	2,139	2,139	2,139	2,914	2,914	2,914	3,166	3,166	3,166
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Job controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Sample consists of high robotization and low GGI countries, which are the Czech Republic, Hungary, Italy, Poland, and Slovakia. The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

We also examine to what extent our results can be explained by compositional changes (in terms of sex, sex-age, sex-education, and sex-occupation) in the manufacturing industry as well as movements in and out of the labor force. Ideally, one would need a large panel of data that follows individuals for a long period to obtain job-cycle profiles of workers. Since such data are not available in a cross-country setting, we examine to what extent workers whose previous job was in manufacturing are still employed in the manufacturing industry. To do so, we turn to the EU-LFS and restrict our attention to workers who are between 20 and 59 years of age for the 20 countries included in our sample.

We present the share of workers in manufacturing (that is, current job in manufacturing industry) whose previous job was also in manufacturing by sex and skill level for all countries included in our sample in Table 5.9.[18] We present outflows from manufacturing (that is, the previous job in manufacturing) to other industries (that is, current job in any other industry) by sex and skill level for all countries included in our sample in Table 5.10. These mobility tables provide descriptive evidence and an indication whether the movements in and out of a given industry due to robotization can drive up the gender pay gap.

The tables show that nearly all workers who used to work in manufacturing are still in the same sector. This is true for all survey years – 2006, 2010, and 2014 and when we construct similar shares by sex and age, sex, and education level nexus. Similarly, few workers whose previous job was in manufacturing moved to other industries, while most moved to another job in manufacturing. We also check this pattern for Germany as it has the highest robotization rate in our sample. The patterns we observe in Germany remain the same (see Appendix 5.A, Table 5.A.11). Collectively, we conclude that compositional changes in the manufacturing sector are negligibly small.

[18]Overall, around 95 percent of workers whose previous job was in manufacturing stay in employment. Around 3 percent become inactive and around 2 percent become unemployed.

Table 5.9: Share of workers currently in manufacturing whose previous job was also in manufacturing, by sex and skill level

	2006						2014					
	Male			Female			Male			Female		
Manufacturing inflows	Low skilled	Medium skilled	High skilled	Low skilled	Medium skilled	High skilled	Low skilled	Medium skilled	High skilled	Low skilled	Medium skilled	High skilled
Belgium	96.2	97.4	98.0	95.8	95.2	95.6	97.8	97.9	97.5	95.5	96.5	96.3
Bulgaria	–	–	–	–	–	–	98.0	99.6	100.0	98.9	98.8	99.3
Czech Republic	96.4	97.3	97.9	96.8	97.2	97.0	98.0	98.3	99.0	97.2	97.3	96.3
Estonia	95.3	94.1	96.4	94.6	94.6	96.6	95.1	97.0	95.4	97.0	96.7	94.1
Finland	98.3	95.9	97.3	95.9	94.7	95.1	98.6	96.7	95.4	98.7	93.8	96.5
France	98.2	98.2	98.2	97.5	97.7	97.6	93.3	96.4	98.0	94.7	92.9	97.2
Germany	98.3	98.9	99.1	98.7	98.5	98.7	97.0	97.6	98.0	96.7	96.9	96.4
Greece	98.5	98.3	99.3	97.6	99.0	98.4	97.9	99.5	100.0	99.0	98.4	98.4
Hungary	95.6	96.6	98.1	97.3	97.5	98.7	96.3	97.1	97.8	97.2	96.1	97.9
Italy	96.6	96.0	95.7	96.8	95.2	94.8	99.0	99.2	99.1	98.5	98.7	98.7
Latvia	88.2	93.6	96.1	94.7	95.2	93.4	96.5	98.1	97.3	95.9	96.7	97.1
Lithuania	94.7	92.6	96.8	93.8	97.5	98.0	93.5	93.7	95.9	97.0	95.4	97.8
Netherlands	97.7	97.7	96.8	97.8	96.0	95.0	96.5	96.9	97.1	92.5	98.8	93.5
Poland	94.7	96.0	96.4	95.8	97.9	97.4	96.5	97.3	98.6	96.4	97.7	98.2
Portugal	96.9	98.0	98.3	98.3	98.9	99.0	98.3	99.1	98.3	99.2	98.2	97.0
Romania	97.4	98.7	98.9	98.5	98.6	98.4	99.1	99.1	99.3	99.4	99.1	99.6
Slovakia	96.3	97.3	97.9	97.6	99.3	97.6	97.8	99.3	99.1	98.9	99.8	98.6
Spain	95.1	96.1	97.4	95.2	91.9	95.4	95.8	97.2	96.2	96.2	94.6	95.4
Sweden	–	–	–	–	–	–	99.3	99.2	99.3	98.7	98.9	99.4
United Kingdom	92.8	93.5	92.9	92.1	92.9	90.6	93.2	96.2	96.0	95.7	87.6	93.9

Notes: This table shows the workers whose previous job was in manufacturing, as a percentage of the workers currently in manufacturing, by sex and skill level. The sample is restricted the employees in Belgium, Bulgaria, the Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and the United Kingdom who are between 20 and 59 years of age. The industry classification is NACE-1. Skill level is defined using the ISCO 1-digit level: the low-skilled category is comprised of elementary occupations and plant, machine operators and assemblers; the medium-skilled category is comprised of clerical workers, service and sales workers, skilled agricultural, forestry and fishing workers and craft and related trade workers; the high-skilled category is comprised of managers, professionals and technicians and associate professionals. Source: EU-LFS and own calculations.

Table 5.10: Outflows from manufacturing to other industries by sex and skill level

	2006						2014					
	Male			Female			Male			Female		
Manufacturing outflows	Low skilled	Medium skilled	High skilled	Low skilled	Medium skilled	High skilled	Low skilled	Medium skilled	High skilled	Low skilled	Medium skilled	High skilled
Belgium	2.3	3.4	2.5	3.5	4.2	2.1	1.8	2.8	1.5	1.4	3.2	3.0
Bulgaria	–	–	–	–	–	–	0.9	0.4	0.7	0.8	1.2	3.7
Czech Republic	2.1	2.0	2.1	1.1	4.5	2.3	1.5	1.1	1.0	0.4	2.7	0.7
Estonia	6.9	8.7	4.1	2.7	8.8	2.9	4.9	5.0	3.6	1.2	7.2	3.4
Finland	3.1	4.1	2.2	2.3	2.8	2.2	2.8	3.3	5.7	1.4	7.1	4.2
France	1.3	2.3	1.9	1.0	3.5	3.6	4.8	5.6	3.3	3.4	6.1	6.5
Germany	1.0	0.6	0.6	4.7	1.7	1.3	1.9	2.0	1.5	3.1	2.7	3.1
Greece	1.4	1.4	1.1	1.4	1.5	2.4	0.8	0.7	0.5	0.2	1.8	3.6
Hungary	3.7	3.0	2.3	1.6	3.8	3.7	2.9	2.6	1.8	1.8	4.0	4.1
Italy	3.2	4.5	5.1	2.8	6.2	8.5	0.6	0.4	0.3	0.8	1.1	0.7
Latvia	15.1	9.7	11.6	5.3	8.4	19.8	5.7	3.0	5.8	1.7	2.1	0.6
Lithuania	5.1	4.8	1.1	6.5	3.3	4.5	5.3	4.5	5.9	1.4	3.5	1.3
Netherlands	1.9	2.7	3.4	2.5	5.3	4.3	2.2	1.1	2.1	3.9	4.7	4.0
Poland	3.2	2.2	2.4	1.6	1.6	2.0	2.4	1.7	2.0	0.5	2.1	2.2
Portugal	1.6	2.0	1.7	2.5	1.3	2.9	1.3	0.9	1.3	0.5	2.3	1.9
Romania	4.3	1.1	1.1	3.7	1.3	2.7	0.7	0.7	1.2	0.1	0.5	2.1
Slovakia	2.3	1.6	1.3	1.0	2.1	0.8	1.2	1.0	1.1	0.7	2.0	2.3
Spain	3.6	4.0	3.1	3.6	8.5	5.8	3.2	3.0	3.7	4.1	4.5	3.8
Sweden	–	–	–	–	–	–	0.8	1.5	0.9	1.5	1.1	1.2
United Kingdom	1.7	1.5	1.0	0.5	3.1	1.5	3.5	3.4	2.2	3.3	7.4	4.7

Notes: This table shows the percentage of workers whose previous job was in manufacturing and who currently work in another industry by sex and skill level. The sample comprises those workers whose previous job was in manufacturing, and is restricted to employees in Belgium, Bulgaria, the Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and the United Kingdom who are between 20 and 59 years of age. The industry classification is NACE-1. Skill level is defined using the ISCO 1-digit level: the low-skilled category is comprised of elementary occupations and plant, machine operators and assemblers; the medium-skilled category is comprised of clerical workers, service and sales workers, skilled agricultural, forestry and fishing workers and craft and related trade workers; the high-skilled category is comprised of managers, professionals and technicians and associate professionals. Source: EU-LFS and own calculations.

In addition to the descriptive evidence we draw from the EU-LFS, we provide further evidence on the sex composition of our sample in Table 5.11. In particular, we analyze whether robotization impacts the sex composition in the demographic cells in our data. The outcome variable is the gender pay gap in the hours worked in the last month, which measures the intensive margin of labor supply of women relative to men. Column 1 reports the results for the full sample, columns 2 to 4 report the results for subsamples of the low-, medium-, and high-skilled occupational groups, respectively. The point estimates are small in magnitude and statistically insignificant, suggesting that robotization did not affect the sex composition in the sample.

Table 5.11: Effect of robotization on the gender gap in hours worked last month

Sample	Full sample	Low-skilled	Medium-skilled	High-skilled
	(1)	(2)	(3)	(4)
Panel A: OLS – outcome: gender gap hours worked				
Robotization	0.000	-0.002	0.001	-0.000
	(0.001)	(0.002)	(0.001)	(0.000)
Panel B: IV replaceable hours – outcome: gender gap hours worked				
Robotization	0.006	-0.008	0.011	0.006
	(0.007)	(0.010)	(0.008)	(0.005)
First stage F-stat	16.37	14.77	19.15	16.09
Observations	24,215	6,399	7,991	9,825
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes
Job controls	Yes	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes	Yes

Notes: The table reports results from OLS and IV regressions of the gender gap in hours worked on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

In summary, our results are likely to be explained by an increase in male earnings in medium- and high-skilled occupations, which is primarily to do with the male predominance in the higher occupational hierarchy. In other words, women's

underrepresentation in higher-skilled occupations accompanied by robotization exacerbates the gender pay gap.

5.7 Conclusions

We provide the first large-scale evidence on the impact of industrial robots on the gender pay gap using data from 28 million individuals living in 20 European countries and covering the period from 2006 to 2014. For identification, we follow prior research and instrument robot adoption with a measure of the fraction of each industry's hours worked in 1980 that was performed by occupations that became replaceable by robots by 2012 (Graetz & Michaels 2018).

We find that, overall, robotization increases the gender pay gap. Our IV estimates suggest that a 10 percent increase in robotization leads to a 1.8 percent increase in the gender pay gap. We further present evidence that these results are driven by countries with high initial gender inequality. Moreover, our results appear to be explained by disproportionate increases in male earnings, compared to female earnings, in medium- and high-skilled occupations. This suggests that skilled men disproportionately benefit from robotization, through a productivity effect.

Automation sets important challenges for labor market policy. While much attention has focused on the overall labor-replacing consequences of technological developments, our findings highlight that automation may have important distributional consequences, which depend on country context and occupational hierarchies. Specifically, our findings suggest that countries that have been less successful in promoting gender equality are also worse equipped to deal with technological developments that may exacerbate gender inequalities.

At a time when policymakers are putting increased efforts into tackling gender gaps in the labor market, our evidence is important. Our results suggest that governments not only need to ensure that education and vocational training systems provide people with the right skills demanded in the future, but also need to pay attention to specific groups of people. They need to increase efforts to make

sure that women and men are equally equipped with the skills most relevant for future employability and that women are equally represented in positions across the skill-based occupational hierarchy.

5.A Appendix tables

Table 5.A.1: Effect of robotization on gender gap in monthly earnings, IV robotic arms

	(1)	(2)	(3)	(4)	(5)
Panel A: IV robotic arms 1st stage – outcome: robotization					
Robotic arms	9.103**	8.725***	7.834***	9.099***	9.002***
	(3.787)	(3.300)	(2.933)	(2.830)	(2.786)
Panel B: IV robotic arms 2nd stage – outcome: gender pay gap					
Robotization	0.021*	0.025	0.015	0.014	0.014
	(0.012)	(0.017)	(0.016)	(0.014)	(0.015)
First stage F-stat	5.778	6.988	7.135	10.34	10.44
Observations	24,215	24,215	24,215	24,215	24,215
Country fixed effects	No	Yes	Yes	Yes	Yes
Year fixed effect	No	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes	Yes
Job controls	No	No	Yes	Yes	Yes
Sex composition	No	No	No	Yes	Yes
ICT capital	No	No	No	No	Yes

Notes: The table reports results from OLS and IV regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.2: Robustness check: alternative demographic cell

	(1)	(2)	(3)	(4)	(5)
Panel A: OLS – outcome: gender pay gap					
Robotization	0.011**	0.010**	0.009**	0.009**	0.009**
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Panel B: IV replaceable hours – outcome: gender pay gap					
Robotization	0.057***	0.064***	0.072***	0.074***	0.074***
	(0.020)	(0.023)	(0.025)	(0.028)	(0.028)
First stage F-stat	15.37	15.98	13.22	11.76	11.87
Observations	4,927	4,927	4,927	4,927	4,927
Country fixed effects	No	Yes	Yes	Yes	Yes
Year fixed effect	No	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes	Yes
Job controls	No	No	Yes	Yes	Yes
Sex composition	No	No	No	Yes	Yes
ICT capital	No	No	No	No	Yes

Notes: The table reports results from OLS and IV regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.3: Robustness check: variation of sample

Outcomes	Male earnings	Female earnings	Gender pay gap
	(1)	(2)	(3)
Panel A1: OLS, sample without Germany			
Robotization	0.015***	0.010**	0.004**
	(0.005)	(0.004)	(0.002)
Panel A2: IV replaceable hours, sample without Germany			
Robotization	0.046	0.021	0.021*
	(0.029)	(0.022)	(0.011)
First stage F-stat	15.99	15.99	15.99
Observations	23,031	23,031	23,031
Panel B1: OLS, sample without automotive/transportation industry			
Robotization	0.015***	0.010**	0.005**
	(0.006)	(0.005)	(0.002)
Panel B2: IV replaceable hours, sample without automotive/trans. industry			
Robotization	0.047	0.020	0.022*
	(0.031)	(0.023)	(0.013)
First stage F-stat	12.72	12.72	12.72
Observations	22,519	22,519	22,519
Country fixed effects	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes
Job controls	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes

Notes: The table reports results from OLS and IV regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.4: Robustness check: alternative measures for outcome variable

Outcomes	Gender gap monthly earnings (PT not adjusted)	Gender gap hourly earnings
	(1)	(2)
	Panel A: OLS	
Robotization	0.004*	0.004*
	(0.002)	(0.002)
	Panel B: IV replaceable hours	
Robotization	0.025*	0.018*
	(0.011)	(0.010)
First stage F-stat	16.37	16.92
Observations	24,215	23,719
Country fixed effects	Yes	Yes
Year fixed effect	Yes	Yes
Demographic controls	Yes	Yes
Job controls	Yes	Yes
Sex composition	Yes	Yes
ICT capital	Yes	Yes

Notes: The table reports results from OLS and IV regressions of the gender gap in median monthly earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.5: Alternative functional form: regressor ln + 1 in robotization

Outcome	ln (Male earnings) (1)	ln (Female earnings) (2)	Gender pay gap (3)
	Panel A: OLS		
ln (robotization + 1)	0.029***	0.022***	0.007*
	(0.008)	(0.007)	(0.003)
	Panel B: IV replaceable hours		
ln (robotization + 1)	0.046*	0.023	0.019*
	(0.027)	(0.021)	(0.011)
1st stage F-stat	21.97	21.97	21.97
Observations	22,458	22,458	22,458
Country fixed effects	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes
Job controls	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes

Notes: The table reports results from OLS and IV regressions. The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. The elasticity estimate is calculated following Bellemare and Wichman (2020). Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.6: Bootstrapped standard errors

Outcome	Male earnings	Female earnings	Gender pay gap
	(1)	(2)	(3)
Panel A: Standard errors two-way clustered			
Robotization	0.010***	0.008**	0.002*
	(0.004)	(0.003)	(0.001)
Panel B: Standard errors bootstrapped and two-way clustered (400 repetitions)			
Robotization	0.010***	0.008***	0.002**
	(0.002)	(0.002)	(0.001)
Observations	24,215	24,215	24,215
Country fixed effects	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes
Job controls	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes

Notes: Comparison of results with bootstrapped standard errors (400 repetitions) vs standard errors clustered two-way (both unweighted). Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.7: Quantile regressions

Quantile	0.1	0.3	0.5	0.7	0.9	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Quantile regressions – outcome: male earnings						
Robotization	0.015***	0.010***	0.008***	0.007***	0.004***	0.010***
	(0.005)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
R-squared	0.915	0.922	0.924	0.921	0.909	0.925
Panel B: Quantile regressions – outcome: female earnings						
Robotization	0.013***	0.008***	0.007***	0.006***	0.003*	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
R-squared	0.924	0.931	0.932	0.931	0.922	0.933
Observations	24,215	24,215	24,215	24,215	24,215	24,215
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Job controls	Yes	Yes	Yes	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports results from quantile regressions of the IHS (inverse hyperbolic sine transformation) of male (columns 1 and 2) and female (columns 3 and 4) earnings on the robotization (that is, inverse hyperbolic sine transformation of changes in number of robots per 10,000 workers). All regressions include a constant. Demographic controls include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Standard errors in parentheses, clustered at the country level. Data unweighted. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.8: Heterogeneity across Eastern and Western Europe

Subsample	Western Europe (1)	Eastern Europe (2)
Panel A: OLS - outcome: gender pay gap		
Robotization	0.004**	0.008**
	(0.002)	(0.003)
Panel B: IV replaceable hours - outcome: gender pay gap		
Robotization	0.019*	0.023*
	(0.011)	(0.012)
1st stage F-stat	16.37	10.53
Observations	24,215	12,870
Country and year FE	yes	yes
Demographic and job controls	yes	yes
Sex composition	yes	yes
ICT capital	yes	yes

Notes: Western European countries include Belgium, Finland, France, Germany, Greece, Italy, Netherlands, Portugal, Spain, Sweden, and UK. Eastern European countries include Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia. The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.9: Gender Gap Index (GGI) scores

Country	GGI score 2006	Classification
Italy	0.65	0
France	0.65	0
Greece	0.65	0
Hungary	0.67	0
Czech Republic	0.67	0
Slovakia	0.68	0
Romania	0.68	0
Poland	0.68	0
Bulgaria	0.69	0
Portugal	0.69	0
Estonia	0.69	1
Lithuania	0.71	1
Belgium	0.71	1
Latvia	0.71	1
Netherlands	0.73	1
Spain	0.73	1
United Kingdom	0.74	1
Germany	0.75	1
Finland	0.8	1
Sweden	0.81	1

Source: World Economic Forum Gender Gap Index by Hausmann et al. (2006).

Table 5.A.10: Heterogeneity by skill-based occupational groups for countries with high robotization and high gender equality

Occupational group	Low-skilled			Medium-skilled			High-skilled		
Outcomes	Gender gap in earnings	IHS male earnings	IHS female earnings	Gender gap in earnings	IHS male earnings	IHS female earnings	Gender gap in earnings	IHS male earnings	IHS female earnings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: OLS									
IHS Robotization	0.002	0.011***	0.009**	0.005*	0.009*	0.003	-0.001	0.006	0.007
	(0.003)	(0.002)	(0.004)	(0.003)	(0.005)	(0.004)	(0.000)	(0.004)	(0.004)
Panel B: IV replaceable hours									
IHS Robotization	-0.005	0.015	0.026**	0.019***	0.023	-0.001	-0.001	0.024**	0.027***
	(0.008)	(0.020)	(0.012)	(0.007)	(0.018)	(0.013)	(0.000)	(0.012)	(0.010)
1st stage F-stat	21.44	21.44	21.44	18.99	18.99	18.99	23.68	23.68	23.68
Observations	1,341	1,341	1,341	1,861	1,861	1,861	2,226	2,226	2,226
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demogr. controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Job controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sex composition	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ICT capital	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Sample consists of high robotization and high GGI countries, which are Belgium, Germany, Spain, the Netherlands, and Sweden. The instrumental variable is a measure of the share of hours in an industry performed by occupations prone to be replaced by robots. All regressions include a constant. Demographic characteristics include three age group dummies and seven occupational group dummies. Job controls include the share of full-time workers and a dummy indicating firm size is larger than 250 employees. Sex composition controls include the share of females and the change in share of females in a cell. ICT capital denotes the IHS of changes in ICT capital. Robust standard errors in parentheses, clustered two-way by country and industry, and adjusted for small number of clusters. Within-country industry employment shares used as survey weights. * p<0.1, ** p<0.05, *** p<0.01. Sources: EU-SES, IFR, EU KLEMS, own calculations.

Table 5.A.11: Inflows to manufacturing by sex, age and education level

Year	Category	Previous job in manufacturing	Moved to another industry
2006	Male, 20-39 yrs., high school or less	98.23%	1.05%
2006	Male, 20-39 yrs., degree-level education	98.87%	0.75%
2006	Female, 20-39 yrs., high school or less	98.24%	1.26%
2006	Female, 20-39 yrs., degree-level education	100.00%	1.06%
2006	Male, 40-59 yrs., high school or less	98.73%	0.68%
2006	Male, 40-59 yrs., degree-level education	99.77%	0.68%
2006	Female, 40-59 yrs., high school or less	98.75%	1.1%
2006	Female, 40-59 yrs., degree-level education	98.73%	2.5%
2010	Male, 20-39 yrs., high school or less	98.27%	1.6%
2010	Male, 20-39 yrs., degree-level education	98.50%	1.5%
2010	Female, 20-39 yrs., high school or less	97.14%	2.55%
2010	Female, 20-39 yrs., degree-level education	98.36%	1.64%
2010	Male, 40-59 yrs., high school or less	98.98%	0.94%
2010	Male, 40-59 yrs., degree-level education	99.61%	0.39%
2010	Female, 40-59 yrs., high school or less	98.32%	1.49%
2010	Female, 40-59 yrs., degree-level education	100.00%	0%
2014	Male, 20-39 yrs., high school or less	96.17%	3.89%
2014	Male, 20-39 yrs., degree-level education	95.71%	1.47%
2014	Female, 20-39 yrs., high school or less	94.43%	4.37%
2014	Female, 20-39 yrs., degree-level education	87.80%	0%
2014	Male, 40-59 yrs., high school or less	97.97%	1.18%
2014	Male, 40-59 yrs., degree-level education	98.95%	0%
2014	Female, 40-59 yrs., high school or less	96.98%	1.91%
2014	Female, 40-59 yrs., degree-level education	91.18%	6.06%

Notes: The third column of the table shows workers whose previous job was also in manufacturing, as a share of the workers currently in manufacturing. The fourth column shows workers who moved out of manufacturing, that is, workers currently working in any other industry as a share of the workers whose previous job was in manufacturing. The sample is restricted the employees in Germany who are between 20 and 59 years of age. The industry classification is NACE 1-digit level. Source: EU-LFS.

Chapter 6

Conclusion

The aim of this thesis is to improve our understanding of the persistent gender gaps in labour market outcomes. The four papers explore questions relating to key areas and sources of these gaps. In this chapter, I summarise the main results of the papers and discuss how the findings contribute to existing knowledge. I then discuss the main limitations of the research. Finally, I consider implications for policy and describe useful areas for future research.

6.1 Summary of findings and contributions

Do gender roles matter for young adults' university major choices?

In Chapter 2, I estimate to what extent and why the degree of femininity of mothers' occupation and the degree of masculinity of fathers' occupation affect whether their adult children choose typically male or female majors at university. To do so, I introduce a novel measure to operationalise the extent to which majors and occupations are 'typically female' or 'typically male'.

I find that sons choose more typically male majors if their fathers worked in more typically male occupations. Daughters choose more typically female majors if their fathers worked in less typically male occupations and if their mothers worked in more typically female occupations. However, mothers' occupation only matters under

certain conditions. The findings suggest that a large part of the intergenerational associations is driven by children choosing a major that is closely related to parental occupation. This provides support for the 'direct transfer of resources' as a relevant transmission channel. This channel includes the transfer of occupation-specific skills, resources, and networks from parents to their children. The results also suggest that some of the father-son associations are due to the transmission of gender roles.

This paper makes three contributions to existing literature. First, it improves the understanding of gendered major choices by providing the first country-specific analysis on the role of parental socialisation, a previously unexplored determinant in Germany. Second, the paper uses a new rank-based measure, which defines the degree of masculinity or femininity relative to others of the same cohort and gender. Finally, the paper contributes to the literature on the intergenerational transmission of gender norms by distinguishing between two main channels through which intergenerational transmission occurs. These channels are the transmission of parental resources and the transmission of gender roles.

Are gender role attitudes sensitive to context and experiences?

The main conclusion from Chapters 3 and 4 is that gender role attitudes are sensitive to context and life-course experiences. In Chapter 3, I study the impact of the 2007 paid parental leave reform in Germany on the gender role attitudes of affected parents; specifically, attitudes towards (i) the gender division of work, (ii) the consequences of the labour force participation of mothers for children's wellbeing, and (iii) fathers' appropriate roles. I find that the reform increased support for traditional gender roles for fathers among parents affected by the reform, compared to parents before the reform. I find no effect on the other two outcomes: attitudes towards the gender division of work, and attitudes towards the consequences of the labour force participation of mothers. I further find that the effect on increased support for traditional gender roles for fathers is driven by a change in attitudes of men, and not women.

This paper makes three contributions: First, it improves our understanding of

the possible effects of parental leave policies on the gender role attitudes of parents by providing the first analysis of the impacts of the 2007 parental leave reform on parental attitudes. Second, it adds to the empirical literature on the effects of the German reform by providing a potential mechanism for the economic effects that previous research has identified. In particular, the paper finds that the reform was successful in achieving increased leave-taking among fathers and a quicker return to work among mothers, but did not lead to significant changes regarding gender equality in paid and unpaid work. Third, results inform the broader literature on whether individual attitudes change over the life course, suggesting that impressionability may not always run in the 'right direction' but may have unintended consequences.

In Chapter 4, jointly written with Mireia Borrell-Porta and Joan Costa-Font, I study the effect of parenting daughters on attitudes towards gender roles in the UK; specifically, attitudes towards the traditional male breadwinner norm in which it is the husband's role to work and the wife's to stay at home. We find robust evidence that parenting daughters decreases fathers' likelihood to hold traditional attitudes. This result is driven by fathers of school-aged daughters, for whom the effects are robust to the inclusion of individual fixed effects. The effect on mothers' attitudes is generally not statistically significant.

The paper makes several contributions to existing literature. It is the first paper to explore the impact of having daughters across daughters' ages on individual changes in attitudes towards gender norms. This is important because our findings suggest that it is when daughters are of school-age - and not before - that fathers' attitudes become less traditional, thus coinciding with the period in which children experience a stronger social pressure to conform to gender norms (Lane et al. 2017). The paper also contributes to expanding the evidence beyond the US, being the first paper to explore the impact of a child's sex on attitudes towards gender norms in the UK. Finally, and unlike previous studies, we draw on data that covers very recent years - up to 2012 - which is important given the large changes in patterns of gender inequalities during recent decades.

Chapters 3 and 4 study different contexts. However, some conclusions on the impressionability of attitudes can be drawn from a joint look at the chapters' findings. First, the results suggest that context can affect attitudes, even among adults. Therefore, the findings oppose the view that attitudes are formed in childhood and youth and remain stable thereafter. Second, in both papers the exposure affects the attitudes of men but not those of women. In both papers, one can argue that the change in experience is stronger for men than for women. Therefore, it seems plausible that attitudinal change occurs for men but not women. In line with identity theories, the new experiences may have altered the parenting identities of men. Especially given that Chapter 2 showed that the transmission of gender roles seems to matter most for young men's gender-typical university major choices, the impressionability of men's attitudes is an important finding.

Does technological change make gender inequality worse?

In Chapter 5, jointly written with Cevat Giray Aksoy and Berkay Özcan, I study the effect of one specific type of automation, industrial robots, on the gender pay gap in a sample of 20 European countries. We find that robot adoption increases both male and female earnings but also increases the gender pay gap. These results are driven by countries with high initial levels of gender inequality and can be explained by the fact that men at medium- and high-skilled occupations disproportionately benefit from robotization, through a productivity effect. These findings suggest that technological change may exacerbate existing gender inequality, especially in contexts where gender differences are already large. This paper contributes to existing literature by providing the first large-scale, cross-country evidence on the gender-specific labour market impacts of industrial robots.

Overall contributions

Each of the four papers addresses its own research question in a different context, using the best available data sources. However, a joint look at the papers yields

additional insights.

First, the papers highlight the importance of focusing research and policy efforts on men as well as women to address gender gaps. Chapter 2 showed that the associations between gender-typicality of parental occupation and gender-typicality of children's university majors are most apparent between fathers and sons. Chapters 3 and 4 confirmed the well-established finding that on average, men hold more traditional attitudes towards gender roles. The chapters also revealed that the experience of parenting daughters and the eligibility for a new parental leave benefit affected the attitudes held by fathers, while leaving those held by mothers unchanged. Finally, Chapter 5 showed that the increase in the gender pay gap due to robotisation was likely explained by the disproportional gains from productivity increases that skilled men can reap.

Despite this, attention often concentrates on the notion that women need to change their behaviour. For example, arguments focus around getting more women into STEM fields, and getting women to return to the labour force relatively quickly after childbirth. However, findings from my papers illustrate the need to consider women's as well as men's behaviours and attitudes. Therefore, one contribution of my thesis is highlighting the importance of focusing research and policy efforts on men as well as women to close remaining gender gaps.

Second, my papers contribute to the literature in cultural economics by confirming the importance of social context, including social norms and gender role attitudes. Chapter 2 demonstrated that the transmission of gender roles plays part in the major choices of young men. Moreover, the findings were at least partially driven by sons who defy gender-stereotypical major choices and suggested that fathers in gender-atypical occupations can help break gender stereotypes. Chapter 3 highlighted that family policy can affect gender role attitudes, which in turn may be a mechanism for the policy's effectiveness to achieve its aims. Chapter 4 revealed that the experience of parenting daughters affected fathers' attitudes as well as behaviours concerning the gender division of work. Chapter 5 showed that the effect of robotisation on the gender pay gap depended on existing gender inequality in a

given country.

Therefore, the thesis contributes to an improved understanding of some of the multifaceted ways in which contextual factors matter, specifically how gender norms and beliefs are formed, and how they interact with gendered behaviour.

6.2 Limitations

I discussed limitations in the relevant sections in each chapter. In this section, I highlight the key limitation of each paper and also discuss limitations that are common to more than one chapter.

In Chapter 2, an important limitation is the extent of information available on parents. Specifically, information on employment histories of parents such as the number of hours worked would be useful to test potential channels for why fathers' occupation matters more for children's choices than mothers' occupation. It is plausible to assume this is because fathers often have the 'more successful' career while mothers only work few hours part-time. However, it is not possible to test this given the data limitations.

The key limitation of Chapter 3 is the small sample size. Because of this constraint, I could not use a strictly causal identification strategy, and I could not conduct separate analyses for East and West Germany, and potentially other relevant subgroups. I conducted a number of robustness checks and sensitivity analyses to increase confidence that my results were not a product of a selected sample or endogenous selection into treatment.

In Chapter 4, an important limitation is that the paper does not test any potential mechanisms through which attitudinal change occurs. However, being the first paper to identify an age-of-daughter specific effect is an important contribution to existing literature.

In Chapter 5, a key limitation is that longitudinal data or data containing the work history of individuals does not exist for the large sample of European countries that we study. Because of this, the sample consists of employed individuals only

and it is not possible to assess how robotisation affects employment. To address this, we endeavour to rule out that gender differences in employment effects are driving our results on earnings. Another limitation common to existing research on the labour market effects of industrial robots is that they are largely quiet on underlying mechanisms.

The aim of my thesis is to improve knowledge concerning some of the important sources of gender gaps in labour market outcomes that were discussed in Chapter 1. It is important to acknowledge that I did not consider all areas of gender gaps in the labour market, for example, gender gaps in self-employment or wealth. Moreover, I did not provide a complete discussion of all factors that contribute to gender differences, including important factors such as labour market discrimination.

Relevant to Chapters 3 and 4, I assumed in this thesis that self-reported gender role attitudes are accurate reflections of individuals' beliefs. However, with the high public awareness of the importance of gender equality, it is possible that social desirability bias affects stated attitudes (Krumpal 2013). Moreover, it is possible that such a potential bias differs systematically across groups. For example, higher-educated individuals may be more aware of issues of gender inequality in the labour market and therefore more susceptible to underreport gender-traditional attitudes.

Finally, it is important to keep in mind that gender social norms may affect behaviour subconsciously and this may not necessarily be reflected in stated gender role attitudes. However, despite their limitations, gender role attitudes remain important indicators of the social climate concerning gender equality (Blohm & Walter 2018). Moreover, in Chapters 3 and 4, they are the best available measures to capture individuals' beliefs about the appropriate roles of men and women.

6.3 Implications for policy

It is beyond the scope of this thesis to give specific policy recommendations. However, the findings of the papers feed into debates on policy design.

The findings in Chapter 2 confirmed the relevance of gendered behaviour of

parents for the gendered university major choices of young adults, especially for young men. This affirms the importance of measures to combat gender stereotypes and norms through a variety of means. Such policies are now widely discussed, and international organisations and policy makers recognise the relevance of social norms for gendered behaviour, and their consequences on labour market outcomes (e.g. OECD 2017, Unterhofer et al. 2017). Consequently, an increasing number of policy initiatives aim to tackle existing gender norms and stereotypes. For example, the German Ministry for Education launched the 'National Pact for Women in MINT Careers', to increase girls' interest in STEM courses.[1] Similarly, the Institute of Physics (IOP) launched the 'Opening Doors' project, to foster good practice in countering gender stereotyping in schools (OECD 2017).

Results from Chapter 2 also demonstrate that policy needs to focus on boys and girls equally, and address male stereotypes as well as female ones. Direct exposure to gender-atypical role models and to gender atypical fields at school are possible ways to do so. Additionally, public campaigns should encourage boys to consider occupations in which men are underrepresented, such as teaching (OECD 2017).

Given the importance of gender social norms, the question whether attitudes towards gender roles are formed early in life or are perceptive to context and experiences is relevant for the design of family policy. The findings from Chapters 3 and 4, highlighting that new experiences can change the gender role attitudes held by parents, are therefore encouraging from a policy perspective. Policy design that considers the normative messages it carries and the potential consequences of new experiences provided through policy incentives on parenting identities may be more effective in achieving desired outcomes. Policy could use normative messages specifically aimed at changing specific norms as a tool.

However, these need to be carefully considered, as conversely, the interaction of policy incentives with parenting identities may produce unintended outcomes. The increase in what I considered 'traditional attitudes towards the role of fathers' due

[1]MINT is the German equivalent of STEM and stands for Mathematik, Informatik, Naturwissenschafen, Technik.

to the 2007 parental leave reform is one such example. Another example is the finding of a recent study from Spain, which shows that the introduction of paternity leave reduced men's fertility intentions (Farré & González 2019). Moreover, family policy that does not take into account the social norms context is often ineffective. For example, while Japan provides the longest paid parental leave entitlements for fathers among OECD countries, only five percent of eligible fathers in 2017 took paid leave (Chzhen et al. 2019).

Attitudes towards gender roles are mainly used to monitor the societal climate and trends at large. An additional implication of my findings is that such attitudes may also be used alongside behavioural outcomes to monitor the effects of gender equality policies.

I discussed evidence that a large part of remaining gender inequalities in labour market outcomes are due to the gendered consequences of parenthood. Therefore, the debate needs to focus on why we see large motherhood penalties. Evidence suggests that an increased provision of childcare and early education helps produce more gender equal outcomes (Olivetti & Petrongolo 2017). However, while some argue that it is crucial that fathers need to be more involved in unpaid work and childcare activities, others argue that the most important step is to enhance temporal flexibility in labour markets (Goldin 2014).

What these arguments have in common is that to achieve gender equality, we need to take into account fathers' behaviour. For example, the expectation in many professional careers to work long hours is an obstacle to achieving gender equality. Enhancing temporal flexibility and reducing disproportionate rewards for long hours and overwork needs to target both men and women. In line with this, Chapters 2 to 4 highlighted the importance to move away from the notion that getting enough women in to STEM fields and increasing incentives for mothers to return to work early is not enough. Instead, there needs to be a more holistic consideration of the changes needed in both women's and men's behaviour to remove systematic gender inequalities.

Finally, the results from Chapter 5 reinforce the importance of gender equality.

Countries with higher occupational segregation, with fewer women in high-skilled occupations, and higher levels of gender inequality may be more susceptible to potentially negative impacts of technological change on gender equality.

To summarise, the findings presented in this thesis alongside related research have several important implications. First, focusing on changing the labour market behaviour of women without addressing that of men and some of its sources – gender stereotypes, norms, and beliefs – will not achieve gender equality. Second, family policy may consider more explicitly the normative messages it carries as well as the effects on parenting identities in order to be most effective. Efforts to close remaining gender gaps in labour market outcomes would benefit from taking a holistic approach which targets both men and women and which considers not only direct financial incentives but also more indirect consequences of policy on social norms and attitudes towards the appropriate roles of men and women.

These considerations are particularly relevant at present, when reactions to the global coronavirus pandemic may be pushing men and women back into their gender-traditional roles, with the potential to erode years of progress.

6.4 Future research

The results of this thesis have implications for research on gender inequality in the labour market. Chapter 2 introduced a rank-based measure of gender-typicality in university majors and occupations. I argued that this constitutes an improvement over previous measures of gender-typicality which are based on gender shares. Rank-based measures could be used in future research on field and occupational choices as well as occupational aspirations. Moreover, the rank-based measure is a first step towards further innovating measures of gender-typicality, and could be adapted and improved based on experimental research on perceptions of gender-typicality.

Chapters 3 and 4 provided evidence that gender role attitudes are sensitive to experience. This is relevant as gendered beliefs seem to guide behaviour particularly in the context of parenthood. There is little research to date on impacts of

policy on attitudinal change and this is an important area for future research, given the increasing recognition of the importance of traditional norms and attitudes for remaining gender gaps.

Research on gender role attitudes involves attitudes towards the gender division of work and attitudes towards the consequences of the labour force participation of mothers for their young children. More research is needed that incorporates more contemporary survey items, such as attitudes towards the role of fathers, and attitudes towards more modern divisions of roles within households. This implies a need for new items in social surveys that account for the changing gender roles. More generally, given the importance of norms and attitudes, attitudes towards gender roles should be incorporated in large longitudinal datasets such as the GSOEP (German Socio-Economic Panel). Survey items should also be extended to cover all key areas of remaining gender inequalities, such as occupational segregation.

Chapter 5 provided the first large-scale, cross-country evidence on the impact of industrial robots on the gender pay gap. More gender-specific empirical evidence on the effects of ongoing technological change is needed and future research that can identify underlying mechanisms is important.

Finally, a point relating to arguments made throughout this chapter is that more research on men and how male gender norms limit their perceived choices is needed. Much policy focuses on changing the choices and behaviour of women and girls. For empirical research to follow this focus, arguably contributes to the problem. This thesis can inform future research that jointly studies the choices, constraints, and norms faced by both men and women, to further improve our understanding of how to achieve gender equality in the labour market.

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