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Occupation Flexibility and the Graduate Gender Wage Gap in the UK

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Non-Technical summary

Developed countries have made significant progress towards gender equality in the workplace, however, a substantial gender wage gap persists in these countries (averaging about 15.5% for the UK in 2020). A large body of research has investigated various factors associated with the persistence of this gap, especially at the top of the distribution, including gender differences in education, industry, and occupational choice. Recent evidence has shown that the motherhood penalty exerts downward pressure on women's pay, as childcare and domestic responsibilities constrain their labour market choices, including their occupations. This paper contributes to this evidence base by looking at how differences in demand and supply of labour in flexible occupations contributes to the evolution of the graduate gender wage gap over the life cycle and over time.

This paper follows Goldin (2014) in defining flexibility as an occupation characteristic that allows workers to choose their hours and location of work without being penalised. Three stylised facts illustrate the patterns related to the gender wage gap and occupation flexibility: (i) While the graduate gender pay gap is small close to labour market entry, it widens over the life cycle as women's earnings growth stagnates after childbirth; (ii) Graduate women increasingly worked in flexible occupations over the life cycle and across successive cohorts over time, whereas graduate men moved out of flexible occupations and did not change their participation patterns over time, and (iii) there is a significant wage penalty arising from working in flexible occupations, conditional on education and age, for both graduate men and women (but not for non-graduates).

These stylised facts raise the question of how gender differences in labour demand and supply in flexible occupations contribute to the gender wage gap. This paper addresses this question using an economic model where individuals in the model are differentiated into types by sex, age, and cohort over time, with each type having different labour market preferences and outcomes. Labour demand is modelled using a nested constant elasticity of substitution production function through which labour of different types are imperfectly substituted between flexible or inflexible occupations to produce output each year. Workers of each labour type observe type-specific equilibrium wages in each year and choose either labour supply in flexible or inflexible occupations or to be in home production.

Results show that the increase in the gender wage gap over the life cycle was primarily driven by increased labour demand over the life cycle for men, particularly in inflexible occupations and especially pronounced till about age 44, increasing their wage premium from working in such occupations at older ages. The results also show that more recent cohorts of women had higher preferences for working in flexible occupations, and this largely drove the increase in women's participation in flexible occupations over time (at any given age), and contributed to increasing the flexibility wage penalty and the gender wage gap over time. Both marriage and childbirth were associated with women being less likely to work. In contrast, men were less likely to work in flexible occupations and more likely to work in inflexible occupations after marriage, while men were more likely to work after fatherhood, especially in inflexible occupations.

Occupation Flexibility and the Graduate Gender Wage Gap in the UK*

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Abstract

This paper examines the importance of gender differences in labour supply and demand for job flexibility to the growth of the gender wage gap over the life cycle and over time for graduates in the UK. We document that the graduate gender wage gap increases over the life cycle, especially between ages 25 and 40, to about 20% of real hourly male earnings by age 55. The share of women working in flexible occupations has grown over the life cycle, and especially substantially over time for successive cohorts, whereas men are less likely to work in flexible occupations at older ages. The wage penalty from working in flexible occupations increases both over the life cycle and over time. We estimate a model of labour supply and demand to quantify the importance of changes to preferences and relative demand for flexibility on the gender wage gap. Higher relative demand for male labour at older ages, and in inflexible occupations, explains almost all (96%) of the estimated life cycle increases in the gender wage gap, whereas women's higher preferences for working in flexible occupations drives the increases in sorting into flexible occupations over time, contributing to about 60% of the estimated increase in the gender wage gap over time.

JEL classifications: J16, J22, J23, J24, J31
Keywords: gender wage gap, occupation flexibility, occupational choice

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1 Introduction

A significant gender wage gap persists in many developed economies (about 20% in the US in 2013 and 15.5% for the UK in 2020) (Blau and Kahn, 2017; Bertrand, 2018; Bailey and DiPrete, 2016; Francis-Devine and Ferguson, 2020). Though the gender wage gap in the UK has fallen since the 1970s, reductions have been slowest at the top of the distribution, as wage convergence was slower over the 1990s for graduates and especially for the highest paid workers, which has mirrored patterns for the US (Guvenen et al., 2014; Bailey and DiPrete, 2016; Bertrand, 2018). This lack of convergence in the gender wage gap over time has been attributed to women's need for flexibility in the workplace, which has led to a 'glass ceiling' that prevents women from accessing highly paid jobs (Bertrand, 2018; Goldin, 2014). This links to an existing literature that links flexibility with the life cycle evolution of the gender wage gap, as the gender wage gap increases over the life cycle, widening after motherhood with the 'child penalty' (Adda et al., 2017; Kleven et al., 2019a; Costa Dias et al., 2018). However, there is little research that explicitly ties occupation flexibility to the changes in the gender wage gap over time and over the life cycle. This paper uses a model of labour demand and supply in flexible occupations to examine how changes in these forces explained the changes in the gender wage gap and the share working in flexible occupations in the UK over time and over the life cycle.

This paper first summarises three key descriptive patterns related to the gender wage gap and occupation flexibility in the UK: first, how the gender wage gap changes over the life cycle and over time for graduates; second, how graduate male and female participation in flexible occupations changes over the life cycle and over time; and third, that graduates suffer a wage penalty from working in flexible occupations which changes over time and over the life cycle. We follow Goldin (2014) in defining flexibility as an occupation characteristic, such that workers are not easily able to choose their hours or location of work in flexible occupations.

The first descriptive pattern shows that the gender wage gap increased over the life cycle for cohorts of graduates born between 1945 and 1985 in the UK, with the graduate gender wage gap at labour market entry close to zero but increasing to about 20% of real hourly male earnings by age 50-55. The magnitude of the gender wage gap remained similar across cohorts over the life cycle at all ages, suggesting that life cycle changes underlie the failure to close the graduate gender wage gap. This increasing wage gap over the life cycle was driven by slower wage growth among women compared to men, which supports the hypothesis in the literature that women's changing work patterns over the life cycle contribute to substantial and sustained reductions in their earnings (Adda et al., 2017; Kleven et al., 2019b; Angelov et al., 2016; Bertrand et al., 2010; Gicheva, 2013). We next illustrate that the share of women working in flexible occupations increased both over the life cycle as well as across cohorts, with an increase of about 2 percentage points over the life cycle compared to about 8 percentage points across successive cohorts. This ties into existing evidence on the motherhood penalty and women's increased demand for flexibility over the life cycle (Cortés and Pan, 2019; Costa Dias et al., 2018; Le Barbanchon et al., 2020; Cortés and Pan, 2020), with it being less established that women have also increased their demands for flexibility over time. On the other hand, men increasingly moved into inflexible occupations at older ages, with little change across cohorts over time. This is in line with existing research that suggests that men have increased working in higher paid ('greedy') occupations over time which pay premiums for working inflexibly or 'overworking', with such occupations also having seen especially high increases in their returns over time (Coser, 1974; Denning et al., 2019; Kuhn and Lozano, 2008). This leads to our next stylised fact that the wage penalty associated with working in flexible occupations increases with age and over time for successive cohorts of both graduate men and women.

The analysis in this paper uses an economic model to try and explain these three descriptive patterns. We focus analysis on prime-aged graduates, as the gender wage gap has not converged as much at the top of the distribution. Furthermore, flexibility might be an especially binding constraint for graduate women who despite working longer hours than non-graduate women, also have been increasingly spending more time with their children (Guryan et al., 2008; Altintas, 2016). The flexibility characteristics used to calculate the flexibility score are also more relevant for high skilled or high earning jobs which tend to be dominated by graduate workers.

We propose a model of labour demand and supply that can rationalise both the cohort and life cycle patterns observed in the data and how they relate to the changes in men and women working in flexible occupations, linking these changes in working in flexible occupations with changes in labour supply to and demand for flexible occupations. We follow Johnson and Keane (2013) in using a model where individuals are differentiated into types by sex, age, and cohort over time, with each type having different labour market preferences and outcomes. On the supply side, workers of different type choose among two market occupations and home production within a random utility framework. On the demand side, workers of different types and in different occupations can be imperfect substitutes in production, with relative demand trends that which can change over time.

We allow occupational choices to vary along the dimensions that we are interested in exploring: flexibility, life cycle, and gender, allowing preferences to vary along these dimensions and in response to other key life events such as marriage and fertility. We aim to capture the heterogeneity in equilibrium wages and employment over time and over the life cycle for different types of workers in the two market occupations (and home production) in this equilibrium model of labour supply and demand. We use the variation arising from demand shifts, changes in tastes and preferences, and heterogeneity across types of labour and occupations to capture changes in the wage structure and employment patterns outlined above in the descriptive trends. Capturing these trends using the model also enables us to perform equilibrium counterfactual simulations to understand how outcomes would be different in response to changes in the parameters.

Our model and parameters of interest illustrate the importance of flexibility in explaining the gender wage gap. We find that increases to women's preferences for flexibility over successive cohorts drove the large increase in women working in flexible occupations over successive cohorts, and contributed to more than 80% of the increase in the wage penalty associated with working in flexible occupations over the same period. This increase in women's preferences for flexibility therefore also contributed to a 62% increase in the model estimates of the graduate gender wage gap between 1993 and 2017. This is comparable to research that has found that close to two thirds of the overall US gender wage gap is accounted for by the differential impacts of children on women and men (Cortés and Pan, 2020). Women's preferences for flexibility may have increased as flexible working has become more common in workplaces, so that cultural norms around flexible working may be more widespread, encouraged by legislation that enables employees to request flexible working arrangements. This shift in preferences towards working in flexible occupations by more recent cohorts of women has not been previously documented, but is in line with previous research that has documented that parental time spent with children has increased particularly for highly educated women in the US and UK, where these increases in human capital investment and assortative matching (Guryan et al., 2008; Borra and Sevilla, 2019; Altintas, 2016; Chiappori et al., 2020, 2017; Lundberg and Pollak, 2014; Lundberg et al., 2016). This evidence on the increased preferences for flexibility conforms to evidence that suggests that increased returns to human capital investment have stimulated more intensive styles of parenting (Doepke and Zilibotti, 2017), showing how these trends in human capital investment and parenting styles are related to the lack of gender wage convergence over time for graduates.

We also find that the relative demand for male labour increased over age, so that men were increasingly in higher demand in both flexible and inflexible occupations at older ages, compared to women, therefore increasing their wage premium in the labour market. This higher relative demand for men at older ages accounted for almost all (or 96%) of the increase in the gender wage gap over the life cycle, as well as 90% of the increase in the flexibility wage penalty over the life cycle as estimated. The increase in the relative demand for labour in inflexible occupations at older ages also explained the increase in the wage penalty from working in flexible occupations for successive cohorts and over the life cycle. This increase in relative demand for inflexible labour is higher for women, however, which contributes to them suffering a higher wage penalty from working in flexible occupations at older ages. The increased relative demand for men at older ages relative to women has been referred to in existing literature as an 'age twist', as research has shown that firms explicit gender requests shifted away from women to men for workers at older ages (Helleseter et al., 2020). It may also be that employers engage in taste-based discrimination against women (due to the gendered nature of employer preferences especially in male dominated professions) or statistical discrimination (due to expectations about lower productivity), (Stillman and Fabling, 2017; Cortés and Pan, 2020). For instance, women were perceived to have lower levels of labour force attachment, especially after motherhood, whereas fathers were seen to be the opposite, and were penalised in terms of receiving fewer call-backs for interviews in field experiments (Kuhn et al., 2020; Correll et al., 2007). Jobs geared towards men and advertising 'male' aspects of flexibility such as shift work and travel had higher advertised salaries in India, also suggesting that employers were more likely to advertise these more senior roles involving inflexible work towards men (Chaturvedi et al., 2021).

While motherhood reduced women's likelihood to work overall in both types of occupations, men were more likely to work after having a child, particularly in inflexible occupations, which corroborates evidence from previous research that has found that fatherhood benefited men in terms of labour market outcomes as they were seen to be more committed and to be recommended higher starting salaries (Lundberg and Rose, 2002; Correll et al., 2007; Kuhn et al., 2020), whereas women were more likely to work in lower-paying firms and family-friendly workplaces with the onset of motherhood (Joyce and Xu, 2019; Hotz et al., 2018; Pertold-Gebicka et al., 2016). We also find that motherhood reduces women's probability of working in flexible occupations more than in inflexible occupations, which suggests that women select into flexible occupations in anticipation of future fertility choices (Adda et al., 2017). Finally, while marriage was also associated with reduced labour supply for women, men reduced their participation in flexible occupations after marriage and were more likely to work in inflexible occupations after getting married, in line existing research that older men were increasingly more likely to work long hours in recent years (Kuhn and Lozano, 2008).

This paper is structured as follows: the following section describes the data and definitions used in analysis, in particular explaining the measure of occupation flexibility that we use, Section 3 summarises the key descriptive patterns of interest, Section 4 sets out the model and estimation strategy, Section 5 presents a discussion of the results for the parameter estimates and counterfactual simulations, and Section 6 concludes.

2 Data

The main data used in analysis is from the UK Quarterly Labour Force Survey waves from summer 1993 to winter 2017, restricting the analysis sample to graduates aged 25 to 55 years (prime-aged population). The data include measures of labour force participation, gross weekly wages, and usual hours worked per week in main occupation, which were used to calculate data aggregates using survey weights to make them representative of the population. This is supplemented with data from the Family Resources Survey on childcare costs and child-related benefits.

Pay was measured as real hourly earnings (with base year set as 2015) in the main job, excluding missing earnings and those with missing weekly hours of work, and trimmed to exclude hourly earnings below £0.10.[1] The hourly earnings used in this analysis exclude self-employment income, as it is typically difficult to separate out labour income for the self-employed, and these are not included in the LFS measure of earnings.

Analysis in this paper focuses on the sample of prime-aged graduates as male and female wages have especially failed to converge at the top of the distribution. The flexibility characteristics used to calculate the flexibility score also may be more relevant for high skilled or high earning jobs which tend to be dominated by graduate workers. Existing evidence also suggests that flexibility constraints may be more binding for graduate women who have been increasingly more likely to spend time with their children than less educated women (Guryan et al., 2008; Altintas, 2016). Convergence of women's earnings to the male distribution was slower for graduates,

[1] 0.1% of observations were trimmed from the sample.

especially at the top of the distribution. Figure 1 plots the change over time in the male to female log earnings ratio across and within occupations at the 10th, 50th, and 90th percentiles for all and graduate full-time employees,[2] and highlights that the disparity between the within-occupation and across-occupation gender gaps is greater for graduates, implying that occupational sorting would play a greater role in hindering pay convergence for graduates.

2.1 Occupation Flexibility

A literature beginning from Autor et al. (2003) has conceptualised occupations in terms of the nature of the tasks involved in performing day-to-day work in that occupation. This strand of research has used this approach to explain how different aspects of occupations such as social skills requirements (Deming, 2017; Cortes et al., 2018), work content (Lordan and Neumark, 2018), or gender differences in task content within occupations (Stinebrickner et al., 2018; Baker and Cornelson, 2016) affect gender segregation and other labour market outcomes.

In a similar vein, this paper follows Goldin (2014)'s definition of flexibility as an occupation characteristic, using five standardised job characteristics from the O*NET survey in the US to define occupation flexibility:

1. time pressure [scale 0-100]: how often the worker is required to meet strict deadlines. The lower the time pressure, the more flexible the occupation is as workers do not have to be around to finish tasks for deadlines very often.

2. contact with others [scale 0-100]: how much the job requires the worker to be in contact with others in order to perform it - face-to-face, by telephone, or otherwise. The more contact the job requires, the less flexible it is as workers are less able to determine their own schedules.

3. establishing and maintaining interpersonal relationships [importance 0-100, level 0-100]: measures how important it is to the job and to what degree that the worker is required to develop and maintain constructive and cooperative working relationships with others (employees or clients). The more relationships the worker has to maintain, the less flexible their working time becomes.

4. structured versus unstructured work [scale 0-100]: the extent to which the job is structured for the worker, as opposed to the worker being allowed to

[2] The across-occupation log earnings ratio at a given percentile is calculated using the distributions of log male and female graduate full-time earnings across all occupations. The within-occupation log earnings ratio is calculated at a given percentile by averaging across all occupations the ratio of log male and female graduate full-time earnings within occupations.

determine tasks, priorities, and goals. The less structure the job imposes on the worker, the more flexibility it allows.

5. decision making freedom [scale 0-100]: measures how much decision-making freedom, without supervision, the job offers. A higher level decision making freedom within the context of performing job tasks means that the job is quite uniquely specified for the worker and therefore other workers would not be able to cover the same tasks - reducing flexibility.

The O*NET is a database listing detailed information about the characteristics of occupations based on surveys of employers in the US, and has been used to study the task content of work. These measures are available for each occupation in the the US Standard Occupational Classification 2000 and were matched to UK SOC2000 4 digit occupations using multiple crosswalks.[3] The flexibility score in each UK SOC2000 occupation in the data was calculated as the arithmetic mean of the reversed characteristics (as each individual characteristic is initially coded with higher values indicating lower flexibility), so that a higher flexibility score indicates an occupation with more flexibility. By definition, the flexibility score is fixed for an occupation over time, as the measure corresponds to O*NET characteristics for a fixed US occupational classification. The binary measure of flexible occupations classifies an occupation as flexible if its flexibility score is above the median flexibility score across all occupations.

Employment and earnings across occupations are influenced by movements in labour demand and supply — workers sort across occupations and firms substitute between employing labour in different occupations based on their preferences for flexibility in these occupations. Much of the existing literature has considered flexibility from the demand side in terms of the motherhood penalty and women's willingness to forgo pay to reduce time spent at work (for example by working part-time, or by being less likely to work extremely long hours). However, flexibility may vary across groups by the occupations they work in because of the nature of the work involved in these occupations.

Defining flexibility as an occupation characteristic categorises occupations by whether the nature of work involved permits greater freedom for workers to schedule where and when their work takes place. For example, occupations requiring a high degree of interpersonal contact in person through meetings (such as health professionals) are less flexible than those that do not have this requirement. Previous research that has considered labour market impacts of the evolution of occupational

[3]Refer to the Data Appendix for detailed information on the construction of these measures.

characteristics has found that aspects that lead to relationship building (social skills) with stakeholders and that require a high degree of abstract thinking have been increasingly in demand (Deming, 2017; Cortes et al., 2018; Autor and Dorn, 2013). Occupations that require a higher degree of these aspects are made less flexible by these requirements however. Management of interpersonal relationships and higher levels of in-person contact (which are related to, but not the same as social skills) in occupations are not explained by considering the time and place flexibility available in a particular working arrangement. Amenities including flexible working arrangements are more related to individual and firm-level choices, rather than required by the nature of the work involved. Furthermore, occupations that demand of high levels of commitment by workers have previously been termed as 'greedy professions', driving trends in increasing overwork (Coser, 1974). These greater commitments on the part of workers are reflected in the components of the flexibility measure, which considers the frequency of interpersonal interactions and the degree to which work is structured, as well as time pressure, as determinants of flexibility in an occupation.

Table 1 describes the characteristics of the most and least flexible three digit occupation groups in the UK SOC2000 for the sample of graduates between 2001 and 2010. An example of an inflexible occupation would be health professionals, who are the least flexible occupation in our sample as they tend to work unpredictable hours, where their presence is required at the workplace. On the other hand, administrative occupations are very flexible with predictable hours and low requirements for workplace presence. Graduates tend to be overwhelmingly employed in less flexible occupations, and underrepresented in more flexible occupations, because of which we separately include the most flexible minor occupation groups,[4] as well as minor occupation groups that employ at least 0.4% of the graduate sample. For example, 9.18% of graduates between 2001 and 2010 were employed as functional managers (e.g. purchasing managers, marketing and sales managers) which is one of the least flexible occupations.

The panels in Table 1 show that lower flexibility scores are associated with managerial and professional roles that potentially involved higher responsibility, whereas more flexible occupations either tend to be junior or vocational roles that may not be quite as demanding in terms of work structure or responsibilities. This is consistent with work on greedy professions (defined initially in Coser (1974) as institutions that seek exclusive and undivided loyalty) and the overwork premium, that suggests that higher paying senior roles or work in industries such as law, finance and con-

[4]Minor occupation groups aggregate more detailed occupation classifications (at the four digit level for the SOC2000) into three-digit groupings, so as to present a greater variety of occupations, as well as to have sufficient graduate share within each occupation group considered.

sulting, require individuals to work long or specific hours in exchange for being paid a premium (Miller, 2019; Cha and Weeden, 2014; Cha, 2010).

Barring health professionals, who scored low on time pressure, all ten of the least flexible occupations scored quite high on all five components of the flexibility measure, indicating that these occupations tend to be inflexible in multiple dimensions. The most flexible occupations tend to be more junior roles (e.g. social welfare associate professionals included here compared to public service professionals being one of the least flexible), and also tend to be more gender segregated than less flexible occupations. The least flexible occupations have highly varying scores for the five component measures of flexibility - for instance, healthcare and related personal services occupations score highly on having contact with others and maintaining interpersonal relationships, but have very low scores on the three other components. However, a score that aggregates all these components is more relevant to this analysis as it is the combination of these different characteristics that defines workplace flexibility – for example, an occupation may allow work to be fairly unstructured but may require much higher than average contact with customers or colleagues, which would then make it less flexible as in the case of public service professionals.

Pan (2015) suggests that one reason for continued gender segregation in occupations is that there is a potential tipping point for female share of occupation employment beyond which men leave the occupation. This may be because the gender composition of an occupation may convey a signal of occupational prestige; partly because of male preferences regarding workplace composition as suggested by the pollution theory of discrimination (Goldin, 2013). Table 1 shows that contrary to this hypothesis, for graduates, though flexible occupations are lower-paid they are more likely to be dominated by men compared to less flexible occupations. This is driven by occupations such as engineers, draughtspersons and architects, and metal machining and instrument trades, skilled graduate occupations that are highly male-dominated, which also tend to not require inflexible working. Individuals who start off working in these occupations tend to progress into managerial roles later into their careers, which would also involve more inflexible working. Flexibility is also not explained by the share working part-time in occupations, which varies substantially across both flexible and less flexible occupations, though more of the flexible occupations have more than half of their workers working part-time.

3 Descriptive patterns in the UK Labour Force Survey

This section describes three key stylised facts related to labour market outcomes for the prime-aged graduate population in the UK from 1993 to 2017: first, how has the gender wage gap changed over the life cycle and over time for cohorts of graduates in the UK? Second, how has the share of graduates working in flexible occupations changed over the life cycle and over time, and how do these changes vary for men and women? Finally, does working in flexible occupations impose a wage penalty on graduates, and if so, does this penalty vary over the life cycle and over time?

Illustrating the first stylised fact, Figure 2a plots the difference in log male and female real hourly earnings from ages 25 to 55 for graduates born in cohorts from 1945-49 to 1985-89 (where available in LFS data from 1993-2017). The graduate gender wage gap at labour market entry was close to zero for all cohorts that we have data around age 25. However, this gap increased steadily at older ages for individuals from these cohorts, peaking at about 30% of real hourly earnings around age 40, and declining a little after that. Although there is a significant increase in the gender wage gap over age, it has remained of similar magnitude when comparing individuals of the same age across cohorts, indicating that changes in the gender wage gap over time mostly reflected changes in the wages paid to male and female graduates of different ages (and differences in age composition across cohorts), rather than changes in the remuneration to graduates of the same age across different cohorts.

Whether this increase in the gender wage gap over age results from male or female wages can be examined in more detail in Figure 2b, which plots the log average real hourly earnings of graduate men and women born in 1965-69 between the ages of 25 to 52. Though graduate men and women in this cohort group had very similar hourly earnings around labour market entry at age 25, their wage growth through even their early career was much slower than that of men, and levelled off earlier by their late thirties. This corresponds to the timing when women would potentially start to require more flexibility at work due to increased childcare responsibilities, and is supported by evidence in the literature related to the 'motherhood penalty' or 'child penalty', where women suffer slower wage growth due to career interruptions and changes to their working patterns after motherhood (Adda et al., 2017; Bertrand et al., 2010; Costa Dias et al., 2018; Kleven et al., 2019b). Men's wages, in contrast, continued growing and only stabilised later into their careers at about age forty-five.

There is a growing literature detailing how the child penalty operates to increase the gender wage gap over the life cycle, with key explanations centred around changes to women's labour supply post motherhood in favour of working options that allow them time and/or place flexibility. For instance, career interruptions, reductions in hours worked, and subsequent loss of human capital due to skill deterioration or lost potential experience, as well as selection into lower-paying or more 'child-friendly' occupations or workplaces closer to home are channels through which having children imposes costs on women and causes the gender wage gap to increase post-motherhood (Angelov et al., 2016; Adda et al., 2017; Bertrand et al., 2010; Costa Dias et al., 2018; Gicheva, 2013; Kleven et al., 2019b). Figure 1b shows that graduate women's earnings caught up to those of their male counterparts *within the same occupation* faster than they did to all graduate men, suggesting that as there was greater wage convergence within occupations than across all occupations, an important explanation for the gender wage gap is in occupational sorting, whereby graduate women and men select into different types of occupations, with women working in lower-paying occupations on average.

It has been documented in the literature is that women are more willing than men to accept lower wages in specific occupations that are more geared towards flexibility and therefore would enable them to manage a career alongside their family (He et al., 2019; Le Barbanchon et al., 2020; Wiswall and Zafar, 2018). This brings us to the next stylised fact on whether the share of graduates working in flexible occupations has changed over time and over the life cycle in the UK. Figure 3 shows the share of graduate men and women of cohorts from 1945-49 to 1985-89 working in flexible occupations (as categorised by a binary measure of flexibility, and as opposed to working in inflexible occupations) over ages 25 to 55. The average share of women working in flexible occupations increased over the life cycle (although by a small magnitude) for each cohort as higher proportions of women selected into these occupations at older ages for all cohorts, as would be expected by existing research on flexibility and the child penalty. On the other hand, there were large increases in the likelihood of working in flexible occupations over the cohorts, as women in later cohorts were much more likely to work in flexible occupations compared to women of the same age in preceding cohorts. Graduate women's participation in flexible occupations increased substantially over time, conditional on age. Unlike the evidence on the motherhood penalty showing women's increasing demand for flexibility over the life cycle, this increase in women's demand for flexibility over time has not been explored much in the literature, though suggestive evidence exists that this may be due to the costs of motherhood having increased as childcare-associated time pressures have risen for recent cohorts of women (Altintas, 2016; Chiappori et al., 2017; Dotti Sani and Treas, 2016; Kuziemko et al., 2018).

In contrast to their female counterparts, graduate men increasingly worked in non-flexible occupations at older ages (moving out of working in flexible occupations over the life cycle on average). This suggests that movements along the career ladder to higher paying occupations coincided with increased working in non-flexible occupations, as more of these higher paying occupations rewarded being able to work inflexibly, which is a channel through which women are unable to experience faster rates of wage growth enjoyed by men in their career progression(Cha, 2010; Cha and Weeden, 2014; Denning et al., 2019). Comparing men of the same age across different cohorts, however, men did not change their participation in flexible occupations over cohorts much, suggesting that the patterns of career progression and movement across occupations remained similar for men of different cohorts. Cha (2013) finds that in comparison to men and childless women, mothers were more likely to exit male-dominated occupations when they worked more than fifty hours per week, whereas other research looking at high-skilled employees (lawyers and MBA graduates) found large earnings penalties for women but not men after the arrival of their first child (Azmat and Ferrer, 2017; Noonan et al., 2005; Bertrand et al., 2010).

Women in particular were willing to accept lower wages in return for being able to work flexibly, as flexible occupations tend to be lower paid on average, indicating a wage penalty from working in flexible occupations. For our final stylised fact, we document this flexibility wage penalty and how it varies over the life cycle and over time. Figure 4 graphically represents the wage penalty associated with working in occupations that score 1SD higher on the continuous flexibility measure, for cohorts of graduate men and women over ages 25 to 55, born from 1945-49 to 1985-89. The flexibility wage penalty is defined as the slope of the regression line associating the median log hourly wage in the occupation with the occupation's flexibility score. The more negative the slope, the larger the wage penalty associated with flexibility. There are no marked gender differences in the evolution of the wage penalty across cohorts and over the life cycle, as for both graduate men and women in every cohort, the flexibility wage penalty increased on average over the life cycle (becoming more negative at older ages), consistent with evidence that higher-paying and more senior occupations on the career ladder are less flexible on average.

The flexibility wage penalty also was higher for graduates in later cohorts compared to those of the same age in earlier cohorts, suggesting that the cost associated with working in flexible occupations increased over time. As the measure of flexibility used in this paper is fixed over time, it does not capture changes in occupations' levels of flexibility over time due to changing regulations or working environments. This evidence, however, is consistent with the findings that the premium for working long hours (or overworking), especially in certain 'greedy occupations' has increased over time (Cha, 2010; Cha and Weeden, 2014; Cortés and Pan, 2019; Coser, 1974; Kuhn and Lozano, 2008), and that the nature of work has changed making it more costly to work flexibly (for example, due to the increased prevalence of group work) (Lazear and Shaw, 2007). The wage penalty associated with flexibility is slightly higher at all ages for graduate women than for graduate men, which is likely due to women being more likely to work in more flexible occupations than men (Cortés and Pan, 2019), as they tend to have a higher willingness to pay for flexibility. For instance, Mas and Pallais (2017) and Bustelo et al. (2020) found using discrete choice experiments that women were likely to be willing to pay more (between 8-20%) for flexible schedules and being able to work from home, with higher estimates of willingness to pay if they had young children.

Finally, we also describe other descriptive patterns related to the other variables used in modelling. Figure 5 plots the change over time in the average hourly childcare costs per child incurred by women who have children under five in the household.[5] Women in the different age groups incurred similar levels off childcare costs over time, where these childcare costs could be up to a third of hourly wages.

Figure 6 plots the change in child-related benefits over time. Figure 6a plots the share of graduates receiving child-related benefits over time, and shows that a negligible share of male graduates are in receipt of child-related benefits, most of which condition on being the primary caregiver of the child. Furthermore, the benefit most relevant for graduates is child benefit, which close to half of all graduate women report as receiving. Child tax credits were introduced in April 2003 along with the Working Tax Credit, and is the most relevant new benefit that was introduced in the period of analysis. Figure 6b shows that the average weekly child-related benefit received by graduate women has increased over time in real value, though the amount is not a substantial portion of weekly wages. Women aged 35-44 receive a higher proportion of such benefits than women in the youngest or oldest age group, suggesting that this is the age group most likely to have children that they are responsible for, and to also receive benefits conditional on having these children.

The patterns described above in the stylised facts suggest that while there may be labour supply forces inducing gender differences in the share of graduates working in flexible versus inflexible occupations over the life cycle and cohorts, interactions with labour demand forces could also additionally result in graduate men and women of different ages and cohorts being remunerated differently.

[5]There is a discontinuity in the data in 2004 arising from differences in how the childcare cost information was recorded - average childcare costs were previously recorded separately for term-time and holiday periods, whereas after 2004 only one average was collected.

4 Model

We use an overlapping generations model as in Johnson and Keane (2013) to examine the role of demand and supply side factors related to occupation flexibility in explaining the gender wage gap for prime-aged graduates over ages 25 to 55 across cohorts.

Individuals in the model are differentiated into types based on their sex (indexed $s \in \{mal, fem\}$), age (indexed $a \in \{25, 26, ..., 55\}$), and cohorts (indexed $c \in \{1945, 1955, ..., 1985\}$) in each year (calendar years indexed as $t \in \{1993, 1994, ..., 2017\}$). Labour market preferences and subsequently outcomes differ for individuals of different types.

4.1 Labour demand

On the demand side of the model, in each period, the aggregate economy wide production substitutes labour in flexible and inflexible occupations (indexed by $o \in \{fle, inf\}$), following a nested CES production function, as follows:

$$Y_t = Z_t \left[\alpha_{1,t} L_{fle,t}^{\rho_1} + (1 - \alpha_{1,t}) L_{inf,t}^{\rho_1}\right]^{1/\rho_1} \tag{1}$$

where Y_t is total output in each year, Z_t is the scale parameter that captures factor neutral technological change and productivity effects at time t. $L_{fle,t}$ and $L_{inf,t}$ are the aggregate labour inputs used in flexible and inflexible occupations, respectively, in each year. ρ_1 a function of the elasticity of substitution between labour inputs in flexible and inflexible occupations ($\sigma_1 = \frac{1}{1-\rho_1}$), and $\alpha_{1,t}$ is a share parameter that captures the intensity with which labour in flexible occupations is used (as opposed to inflexible occupation labour) in each year. Both the scale parameter and the share parameters in the production technology are assumed to vary over time following time trends: i.e. $\ln Z_t = Z_0 + Z_1 t + Z_2 t^2 + Z_3 t^3$ and $\ln \alpha_{1,t} = \alpha_{1,t}^0 + \alpha_{1,t}^1 t + \alpha_{1,t}^2 t^2 + \alpha_{1,t}^3 t^3$. These time trends allow the model to flexibly capture movements in overall productivity as well as in the relative demand for labour in flexible occupations over time.

In the second nest of the production technology, firms aggregate labour of six types (three age groups and two sexes) within each occupation category:

$$L_{o,t} = \left[\sum_{a,s} \alpha_{2,a,o,s} L_{a,o,s,t}^{\rho_2}\right]^{1/\rho_2} \quad \text{for} \quad o = fle, inf \tag{2}$$

$L_{a,o,s,t}$ is the total labour input of age group $a \in \{25-34, 35-44, 45-55\}$ and sex

$s \in \{m, f\}$ used in occupation o in year t, and $\alpha_{2,a,o,s}$ is the share parameter that captures the intensity with which this labour input is used relative to labour inputs of the other sex and age groups, which is fixed over time. [6] ρ_2 is the substitution parameter (defined in relation to the elasticity of substitution as above) governing how labour inputs across different ages are substituted between. The demand side of the model has 22 parameters that need to be estimated.[7]

Labour demand in this framework is modelled using a constant elasticity of substitution (CES) production function where total output Y_t is a function of labour supply $L_{\tau,t}$ of type $\tau \in \tau_1, \tau_2$ at time t:

$$Y_t = \left[\alpha_t L^{\rho}_{\tau_1,t} + (1 - \alpha_t) L^{\rho}_{\tau_2,t}\right]^{1/\rho} \tag{3}$$

α_t is the time-varying share of each type of labour used in production and ρ is the the substitution parameter such that the elasticity of substitution between the two types of labour is $\sigma = \frac{1}{1-\rho}$. As wages equal marginal products of labour in equilibrium, the gender wage gap (expressed as the log ratio of male to female wages) would be a function of the ratios of the relative labour shares for male and female labour as well as the equilibrium quantities of male and female supplied:

$$\log\left(\frac{W_M}{W_F}\right) = \log\left(\frac{\alpha_M}{\alpha_F}\right) - \frac{1}{\sigma}\log\left(\frac{L_M}{L_F}\right) \tag{4}$$

On the demand side, therefore, the relative demands for male and female labour in flexible and inflexible occupations over time and at different ages determine how the gender wage gap evolves over time. On the supply side, however, the ratio of male to female labour supply in each occupation is determined by male and female preferences for working in each occupation as determined in a random utility framework.

4.2 Labour supply

On the supply side, each type of agent in each year chooses between three alternatives: two types of market occupations (flexible or inflexible) and home production (indexed $j \in \{fle, inf, hom\}$). Individuals of different types have different prefer-

[6]The share parameters are fixed over time within each occupation type implying that the structure of firms' relative demand for labour inputs across different ages does not vary over time, given occupation type.

[7]The demand-side parameters include two elasticities of substitution (one for each nest of the production function), four parameters related to the time-varying changes in technology or total factor productivity, and sixteen parameters related to the share parameters (four in the first nest, and twelve in the second nest of the production function).

ences for their three labour supply alternatives, as characterised by the following random utility function:

$$
\begin{aligned}
U(j \mid s,c,a,t) = {} & \psi_{0,s,a,j} + \psi_{0,s,c,j} + \psi_1 W_{a,s,o,t} \cdot \mathbf{1}[j=o] + ... \\
& + \pi_{2,s,j} Pr(\text{child} < 5 = 1 \mid s,a,t) + ... \\
& + \pi_{3,s,j} Pr(\text{marr} = 1 \mid s,a,t) + ... \\
& + \gamma_{1,o} \text{CHC}_{a,t} \cdot \mathbf{1}[j=o] \cdot \mathbf{1}[\text{child} < 5 = 1] \cdot \mathbf{1}[\text{s} = \text{f}] + ... \\
& + \gamma_{2,o} \text{CBEN}_{a,t} \cdot \mathbf{1}[\text{child} < 5 = 1] \cdot \mathbf{1}[\text{s} = \text{f}] + ... \\
& + \epsilon_{j,s,a,c,t} \quad \text{for} \quad j = fle, inf, hom; o = fle, inf
\end{aligned} \tag{5}
$$

$U(j \mid s,c,a,t)$ is the utility from labour supply alternative j obtained by an individual of sex s, cohort c, and age a at time t. $\psi_{0,s,a,j}$ captures age- and sex- specific preferences over the alternatives j that are fixed over time. $\psi_{0,s,c,j}$ captures cohort- and sex- specific preferences over the alternatives j that are fixed over ages. This allows the female share working in flexible occupations for a given cohort to be higher or lower than that of a previous cohort across all ages, for example. ψ_1 is a parameter describing the sensitivity to age-occupation-specific wages in a given year $W_{a,o,t}$, with wages only available for market occupations $o \in \{inf, fle\} \subset j$.

We further explicitly include characteristics that can influence the occupational choice of agents. These include marriage, fertility, childcare costs and child-related benefits. Labour supply preferences for type of occupation or even for labour force participation could be affected by marriage and children, with these preferences likely to play a more significant role for women. The age- and sex-specific likelihoods of being married and having children in a given year are therefore included to account for these differences in preferences, as $Pr(\text{marr} = 1 \mid s,a,t)$ and $Pr(\text{child} < 5 = 1 \mid s,a,t)$ respectively. These likelihoods vary over time and age to capture generational and life-cycle differences in the likelihood of marriage and children for men and women. $\pi_{2,s,j}$ captures sex-specific preferences for home production or the two market occupations, given their type's likelihood of having children, whereas $\pi_{3,s,j}$ captures sex-specific preferences for home production or the two market occupations, given their type's likelihood of being married. These preferences only vary by sex, as it is likely that women have different labour supply responses to these life events than men do.

Average childcare costs CHC are included for women of different age groups in each year if they have children under five in the household, and only if they are working in a market occupation. The childcare costs are calculated as the average hourly childcare costs per child. The disutility from childcare costs differs by occupation through the coefficient $\gamma_{1,o}$. The average child-related benefits $CBEN$ received by graduate women in each year are also included. As these child-related benefits are received by children's primary caregivers, which in most cases are women, so that these terms only enter the labour supply utilities of women. The utility of receiving benefits ($\gamma_{2,o}$) only varies by occupation.

Finally, following a multinomial logit specification, $\epsilon_{j,s,a,c,t}$ is assumed to be distributed independently and identically extreme value, which allows the utilities to be expresed as multinomial choice probabilities. Given utility set up as above, individuals of each type in each year choose one of the three alternatives following multinomial logit choice probabilities as below:

$$Pr(j = 1 \mid s, c, a, t) = \frac{exp\,[U(j \mid s, c, a, t)]}{\sum_j exp\,[U(j \mid s, c, a, t)]} \quad \text{for} \quad j = fle, inf, hom \tag{6}$$

Labour supply for each type to each choice alternative is equal to the type's probability of choosing that alternative multiplied by the size of the cohort for that type of labour.

$$L^{supply}_{s,c,a,t} = Pr(j = 1 \mid s, c, a, t) \times \text{LabourForce}_{s,c,a,t} \tag{7}$$

The supply side of the model has 37 parameters that need to be estimated, of which 24 are gender- and age-/cohort-specific preferences for occupations.

4.3 Equilibrium and Estimation

In equilibrium, wages paid to each type of worker equal their marginal products of labour, which can be obtained from the production technology, for labour of sex $s = \{m, f\}$, occupation $o = fle, inf$, age group $a \in \{25 - 34, 35 - 44, 45 - 55\}$ at time t as below:

$$W_{a,o,s,t} = \frac{\partial Y_t}{\partial L_{a,o,s,t}} \tag{8}$$

Though the marginal products of male and female labour are complex functions of many of the parameters in the production function, the ratio of the marginal products of male and female labour only depend on the ratios of their productivity shares and the relative size of their inputs used in production, and hence the equilibrium male–female wage ratio for age a at time t in occupation o is:

$$\frac{W_{a,o,m,t}}{W_{a,o,f,t}} = \frac{\alpha_{2,a,o,m} L^{\rho_2 - 1}_{a,o,m,t}}{\alpha_{2,a,o,f} L^{\rho_2 - 1}_{a,o,f,t}} \tag{9}$$

Therefore, the log wage ratio can be expressed (using $\rho_2 = \frac{\sigma_2 - 1}{\sigma_2}$) as:

$$\log\left(\frac{W_{a,o,m,t}}{W_{a,o,f,t}}\right) = \log\left(\frac{\alpha_{2,a,o,m}}{\alpha_{2,a,o,f}}\right) - \frac{1}{\sigma_2}\log\left(\frac{L_{a,o,m,t}}{L_{a,o,f,t}}\right) \tag{10}$$

Furthermore, labour supply of each type in each occupation equals the labour of that type demanded in that occupation in equilibrium:

$$L^{demand}_{a,o,s,t} = L^{supply}_{a,o,s,t} \tag{11}$$

The model parameters are identified off the variation in employment and wages for individuals in each type and occupation in the data. The model has 53 parameters in total to to be estimated, 20 from the demand side of the model and 33 from the supply side. Parameter estimates are obtained by targeting the differences between observed and predicted labour supplies and wages and minimising these differences using GMM estimation. Using this approach, a solution is obtained by iteration over a fixed point algorithm, which proceeds as follows: (i) for a given set of parameter values, an arbitrary wage vector W^0 is plugged into the occupational choice model to get the estimated occupational choice probabilities for each labour type, from which labour supplies can be estimated using the cohort sizes for each labour type (Equations 6 and 7); (ii) these estimated labour supplies can be plugged into the marginal productivity function (Equation 8) to get predicted wages W^1; (iii) if the predicted wages W^1 equal W^0, there is a solution for these given parameters, and if not, the iterative process is repeated till there is a solution.

The model generates predictions of wages and labour supplies for (31 ages $\times$ 2 sexes =) 62 types of labour in each of 25 years from 1993 to 2017. There are three labour supply predictions for each type (one for each occupational choice alternative), so that there are 186 labour supply predictions for each year (4650 in total).There are two wage predictions (one for each market occupation) for each type, so that there are 124 wage predictions for each year (3100 in total). These 7750 predictions are optimised with respect to the 59 parameters to minimise the differences between the predictions and observed data.

The elasticities of substitution are identified by how the wages and share parameters respond to variations in labour supplies. If the share parameters ($\alpha_{1,t}$and$\alpha_{2,a,o,s}$) were allowed to vary over time completely, the elasticities of substitution could not be identified as the variation in labour supplies would be completely captured by the variation in demand shares. Similarly, if the preferences or tastes for occupations were allowed to vary completely over time, these would completely capture the effects of wages on occupational choice. Therefore, both of these sets of parameters are constrained to vary over time following specific assumptions, allowing for identification of the remaining parameters.

5 Results

5.1 Model Fit

Figures 7 and 8 show how the predictions of the model fit in relation to the data. These graphs plot the main outcomes that relate to the descriptive trends of interest in Section 3, but averaged over the age groups and cohorts as specified in the model in Section 4. The graphs therefore show the trends in the male-female gender wage gap, the wage penalty for working in flexible occupations relative to inflexible occupations, and the share of men and women working in flexible occupations (versus inflexible occupations).

The plots overall show that the model predictions fit the data relatively well, in general capturing the nature of any trends in the data. Figure 7a shows that the model captures the increase in the gender wage gap over age for all cohorts in its predictions. The trends described in Section 3 showed that the gender wage gap increased substantially over the life cycle, with the levels remaining similar across successive cohorts. The estimates generated by the model fit these observed patterns in the data well, particularly with respect to the large increase in the gender wage gap over the life cycle up to age 35-44 that thereafter plateaus.

The patterns described earlier established that the penalty for working in flexible occupations increased both over the life cycle and across cohorts. In Figure 7b, the model predictions mirror the nature of the increase in the flexibility wage penalty over the life cycle, as well as the increase over cohorts, though the magnitude of this latter increase is slightly overestimated. These patterns suggest that the increase in the flexibility wage penalty, similar to the increase in the gender wage gap, peaked around age 35-44 after which the rate of increase fell.

Figure 8 plots the trends related to the share of men and women working in flexible occupations (as opposed to inflexible occupations). The descriptive trends showed that the share of women working in flexible occupations increased over cohorts and did not change much over age, whereas the share of men working in flexible occupations fell over the life cycle, with levels not changing much over successive cohorts. Figures 8a and 8b show that the share of men and women working in flexible occupations is fairly closely predicted by the model on average. The share of men in flexible occupations fell substantially between ages 25 and 45 for all cohorts, with no further falls or slight increases after that, and this is captured well by the estimates.

On the other hand, while the share of women working in flexible occupations did not increase much over ages (conditional on cohorts), later cohorts of women were much more likely to work in flexible occupations than earlier cohorts. Figure 8b shows that these patterns are mirrored closely in the predicted data. These graphs show that the model captures the overall trends with respect to the outcomes of interest fairly well, and therefore, we next explore how the parameters estimated in the model can explain these observed patterns.

5.2 Parameter Estimates

5.2.1 Demand side

Elasticities of substitution

Table 2 reports the estimates for the substitution parameters and the associated elasticities of substitution in both nests of the production function. The elasticity of substitution between labour in flexible and inflexible occupations is estimated at 1.5. Though there are no directly comparable existing estimates of the elasticity of substitution between labour in flexible and inflexible occupations, this falls in between the elasticity of substitution between physical capital and skilled labour of 0.47, and capital and skilled versus unskilled labour of 3.23, as reported by Johnson and Keane (2013) for the US. On the other hand, the estimated elasticity of substitution between labour of different age groups and sexes within each occupation is much higher at about 38.4, suggesting that these labour types are close substitutes in production, conditional on occupation.

From Table 3, there was a increase in the supply of inflexible relative to flexible labour by about 0.03 log points, which combined with an elasticity of 1.5, implies that there should have been a relative fall in (inflexible–flexible) earnings of about 0.02 log points (Equation 10). However, the relative fall in earnings for inflexible labour was about 0.03 log points, suggesting that there was a larger fall in relative demand for inflexible labour that pushed the log wage ratio down. Similar calculations for male and female labour suggest that the gender wage gap (both overall, and within occupations should have fallen by about 0.01 log points. However, (male/female) relative earnings increased overall, as well as within each type of occupation, suggesting that increases in relative demand for male labour within each occupation type, that outweighed the effect of the increase in relative labour supply, led to further gender disparity in earnings over this period.

Demand trends by occupation, age, and gender

Figure 9 plots the estimates of the relative demand shares of labour of different types and occupations. The plotted relative demand shares are log ratios of the labour types considered, with Figures 9a and 9b showing how these demand shares evolved over the life cycle (as the share parameters are fixed over time in the second nest of the production function). The share parameters in the first nest of the production function vary over time according to a quadratic time trend, and the associated time-varying log ratio of the relative demand for labour in flexible versus inflexible occupations is plotted in Figure 9c. Finally, Figure 9d plots the estimated evolution of total factor productivity, which also follows a quadratic time trend.

Figure 9a shows that the demand for male labour relative to female labour was increasing with age. This trend of increasing relative demand for male labour at older ages occurred in both flexible and inflexible occupations, though the increase in relative demand for male labour at older ages was higher in flexible occupations. The relative demand for male labour increased over the life cycle by about 0.18 log points in flexible occupations, higher than the 0.15 log point increase in inflexible occupations, implying that the increase in the gender wage gap over the life cycle arising due to the increase in relative demand for male labour would have been higher in flexible occupations (by Equation 10). The graph shows that the increase in relative demand for male labour (and therefore the associated upward pressure on the gender wage gap) was strongest between ages 25 and 44, after which the rate of increase slowed in both flexible and inflexible occupations. This is in line with the pattern seen in Figure 2b that showed that male wages grew faster than women's wages till about age 40, after which wage growth stagnated for both men and women, with male wages remaining higher than women's wages throughout.

Figure 9b shows that the demand for labour in flexible occupations relative to inflexible occupations fell over the life cycle for both men and women, so that labour in inflexible occupations was increasingly demanded at older ages. The fall in relative demand for labour in flexible occupations would lead to a downward pressure on relative wages in flexible occupations compared to inflexible occupations, so that the wage penalty for working in flexible occupations would increase over the life cycle. Relative demand for female labour in flexible (versus inflexible) occupations fell by about 0.13 log points, compared to a lower fall of about 0.10 log points in the relative demand for male labour in flexible (versus inflexible) occupations, suggesting that women faced a higher life-cycle increase in the penalty from working in flexible occupations. Furthermore, the fall in the relative demand for labour in flexible occupations was concentrated before age 44, after which it stagnated for both men and women, suggesting that the increase in the wage penalty from working in flexible occupations would also be concentrated in this period, which is seen in the data in Figure 4 and more clearly in Figure 7b.

These two patterns of relative demand suggest that the demand for male labour would increase over the life cycle especially in inflexible occupations, consistent with evidence that has found that women remain underrepresented in the top part of the earnings distribution as there remains a glass ceiling that prevents women from accessing the highest earning positions (Guvenen et al., 2014; Bertrand, 2018). These differences in firm demand (and therefore to male and female earnings) have been previously attributed to labour market discrimination against women, and in particular against working mothers Cortés and Pan (2020); Stillman and Fabling (2017). Discrimination may be taste-based due to differences in firms' preferences for men and women (as women may be seen as contravening gender norms especially in male-dominated environments (Akerlof and Kranton, 2000)), or due to statistical discrimination arising from differenes in expected productivity as women are expected to take more career breaks leading to losses of human capital (Adda et al., 2017; Azmat and Ferrer, 2017; Babcock et al., 2017; Stillman and Fabling, 2017). Other research has gound that women are more willing to take on jobs with 'low promotability', and that gender differences in career aspirations and competitiveness contribute importantly to the gender wage gap, as women are less likely to select educational tracks that are perceived to be more competitive (Babcock et al., 2017; Buser et al., 2014; Machin and Puhani, 2003; Chevalier, 2007). This also suggests that institutional barriers such as lack of mentors and restricted support networks help penalise women's choices in such settings and prevent them from accessing high-paying jobs at top levels.

Related research has found an 'age twist' in hiring behaviour – firms' explicit gender requests on job boards shifted away from women to men for older (versus younger) workers, where part of this twist is explained by employers' requests for older male managers and young women in customer service, and the remainder is likely related to the differential impact of parenthood by gender (Helleseter et al., 2020). Correll et al. (2007) found using a resume audit study that employers called mothers back to interview half as often as childless women, while fathers and childless men were called back at similar rates, suggesting that men were not penalised for (and even sometimes benefited from) fatherhood. Participants in lab experiments judged fathers to be more committed and recommended higher starting salaries, in contrast to mothers being seen as less competent and committed to paid work and recommended lower starting salaries (Correll et al., 2007). A related paper by Kuhn et al. (2020) also found that women experienced a larger call-back penalty of 43% compared to 24% for men, from applying to gender mis-matched jobs.

Chaturvedi et al. (2021) studied gendered word classifications of Indian job advertisements and find that jobs that are geared towards men and have 1SD higher level of words focused on aspects of flexibility such as night shifts, relocation and travel (male-oriented flexibility) had higher advertised wages by about 2.4%, where the female applicant share was also negatively associated with words related to male-oriented flexibility. This suggests that jobs that have higher levels of inflexibility are typically higher paid and likely more senior roles, which therefore reinforces the glass ceiling on women's representation in higher levels of management. Figure 10 shows the change in the share of workplaces with flexible working arrangements (as defined by the survey) over time, using Workplace Employment Relations Survey data.[8] The graph shows that the most relevant change was in the share of workplaces reporting that they used shift work, which increased from about 25% in 1998 to 41% in 2011, suggesting an increase in inflexibility. Figure 11 shows, also using WERS data, that though the average share of women in management positions has increased in UK workplaces between 1998 and 2011 to about 24%, this increase slowed down between 2004 and 2011, suggesting that demand for women in these positions slowed down in these years.

Figure 9c shows that the relative demand for labour in flexible occupations relative to inflexible occupations, estimated by the model following a cubic time trend, fell over time. The decrease in relative demand for flexible occupations would have led to an increase in the wage penalty from working in flexible occupations over time. This pattern can be seen in Figure **??**, which also shows that the increase in the flexibility wage penalty over time slowed for the most recent cohorts, which corresponds to the relative demand for labour in flexible occupations increasing in the most recent years. This slowdown in demand for inflexible jobs aligns with the reversal in the growth of demand for cognitive tasks starting in the tech bust of 2000 (Beaudry et al., 2016). In

[8] The Workplace Employment Relations Survey is a representative national survey of UK workplaces. Data from the 1998, 2004, and 2011 waves were used.

line with this hypothesised slowdown in the demand for high-skilled jobs, the returns to graduate education have become more dispersed as the participation in higher education has widened, suggesting asymmetric polarisation of employment due to high skilled workers being pushed down the career ladder (Green and Henseke, 2016; Naylor et al., 2016; Walker and Zhu, 2008). Finally, Figure 9d shows that there was an overall increase in productivity over time (modelled as a cubic time trend) between 1993 and 2017, with a downturn around 2009, coinciding with the Great Recession in this period.

5.2.2 Supply side

Earnings

Table 4 reports the estimates of the parameters from the supply side of the model, along with the average marginal effects for the main parameters. The estimated coefficient for occupation-specific earnings is 0.7549, with an average marginal effect on the likelihood of working of 0.0119, both of which are positive, suggesting that an increase in the average hourly earnings in an occupation is likely to increase the probability of working by 0.8 percentage points[9]. The wage elasticity of labour supply is the increase in the probability of choosing to work in market occupations as a result of the increase in the average hourly wage.[10] A 10% increase in the average hourly wage in flexible occupations in 1993 from £11.23 to £12.35 results in a 0.02 percentage point increase in the probability of working in flexible occupations, all other things equal, whereas a 10% increase in the average hourly wage in inflexible occupations from £15.54 to £17.09 would result in a 0.001 percentage point increase in the probability of working in inflexible occupations - suggesting that the estimated wage elasticity of labour supply among graduates is quite low on average.

Marriage and Fertility

The estimated coefficients for marriage and fertility show that both life events were associated negatively with women's labour supply, whereas fertility in

[9]The average marginal effects are derivatives of the probability of occupational choice with respect to the predictors in the multinomial logit model. These derivatives are computed as the changes in predicted probabilities of working in an occupation accruing from a change in the predictor for all the labour types in the model. The average marginal effects average these changes in choice probabilities over all labour types.

[10]The probabilities of choosing to work in flexible or inflexible occupations versus home production can be calculated using the multinomial choice probability equation in Equation 6.

particular was positively associated with men choosing to work in both market occupations. The reported average marginal effects are the changes in the probability of choosing the specified occupation associated with a 0.1 percentage point increase in the probabilities of being married or having a child, averaged across all age groups and years. These reported effects show that having a child had a greater effect on reducing women's labour supply than did marriage, with the reduction in labour supply larger for flexible occupations in the case of both life events. For instance, the 11.1 percentage point increase in the likelihood of a 35-44-year-old woman having a child under five between 1993 and 2017 (Table 5) was associated with 8.5 and 18.1 percentage point reductions in the probability of a woman of this age group working in inflexible and flexible occupations respectively. This is in contrast with Cha (2013) who finds that that in comparison to men and childless women, mothers were more likely to exit male-dominated occupations when they worked more than fifty hours per week. However, this finding is more in line with Adda et al. (2017), who suggest that women's occupational choices are likely to have been made with expectations about future fertility and associated penalties for career breaks in mind, and therefore this is indicative of women's greater attachment to the labour market in highly paid, inflexible occupations. Furthermore, women in the UK were much less likely to drop out of the labour market around the time of first childbirth in recent decades, suggesting that women's labour market attachment has grown overall (Roantree and Vira, 2018). On the other hand, fatherhood was likely to increase men's labour supply (which has been previously documented (Lundberg and Rose, 2002)), with larger increases in inflexible occupations than in flexible occupations, which corresponds with the life cycle increase in men's participation in inflexible occupations.

The probability of being married fell over time for both men and women across all age groups, as seen in Table 5. This reduction in the probability of being married led to women increasingly more likely to work, as, for example, the 13 percentage point reduction in the likelihood of being married for women aged 25-34 over the sample period was associated with 0.01 and 0.04 percentage point increases in the probability of working in inflexible and flexible occupations, respectively, suggesting that marriage did not have a large effect to draw women away from the labour force, given fertility and other factors. The reduction in female labour supply due to marriage was greater in flexible occupations than in inflexible occupations. However, men were more likely to work in inflexible occupations after marriage, and this increase was more pronounced than for flexible occupations. This corresponds with evidence that men in particular are able to enjoy a premium from 'overworking' or working inflexibly in highly paid occupations (Cha and Weeden, 2014; Denning et al., 2019), and that older men were more likely to be overworking in recent years (as opposed to previously, when overworking was more common among younger men) (Kuhn and Lozano, 2008).

Childcare costs and child-related benefits

The estimated coefficients for childcare costs show that higher childcare costs were associated with women being less likely to work in market occupations. On the other hand, the receipt of higher levels of child-related public benefits were not associated with large increases in women's labour force participation. The reported average marginal effects are the changes in the probability of choosing the specified occupation associated with a 0.001 increase in the childcare costs accrued and the benefits received conditional on having children, averaged across women of all age groups and years.

The reported average marginal effects show that increased childcare costs had the effect of reducing women's likelihood of working in both flexible and inflexible occupations, as these costs increased the opportunity cost of working in market occupations. Therefore, as women bore most of the childcare responsibilities, they were likely to opt out of participating in the labour market in order to take care of children themselves. A £0.01 increase in weekly childcare costs was associated with 0.6 and 1.0 percentage point reductions in the probability of women working in inflexible and flexible occupations, respectively. For instance in England, the increase in childcare costs outstripped the increase in wages by about three to four times overall between 2008 and 2016(Reland, 2017a,b), and given that women's labour supply is especially dependent on the availability and cost of childcare, this rapid increase in costs would restrict their labour force participation. Lack of childcare especially limits the labour supply of high-skilled women, for whom the outsourcing of domestic production forms a tighter constraint on their time allocation as their workplaces are more likely to demand inflexible hours (Cortés and Pan, 2019; East and Velásquez, 2020). These results are in line with Adda et al. (2017) who find a positive 'utility cost' of childcare incurred when working that affects consumption decisions for German women.

On the other hand, increased provision of public benefits conditional on having children had almost no effect on the labour force participation of women.

This suggests that as child-related benefits are targeted more towards providing low-income mothers with additional income, they are not an important factor in determining the labour force participation of the graduate women in our sample. Other research looking at female labour supply in the UK has found that while the receipt of tax credits have a notable effect on the employment of women with high school or lower levels of education, increasing employment of single women and decreasing that of married women, these receipts are less important for university educated women (Blundell et al., 2016). Research using Austrian data has also found that large increases in parental leave and childcare subsidies (termed 'family policies') have had little impact on increasing gender convergence in the labour market, attributing the lack of effect of childcare subsidies to strong norms around maternal care provision and crowding out of other types of informal childcare (Kleven et al., 2020).

Age- and Cohort-Specific Preferences for Occupations

The model estimates preference parameters that show how gender-specific preferences for working in flexible and inflexible occupations vary over the life cycle and across cohorts, shown in Table 6. Figure 12 plots how the relative probability of working in flexible (compared to inflexible) occupations change with the evolution of these parameters over the life cycle and over cohorts, relative to their earliest values.[11]

Figure 12a shows that there was a large increase in women's relative preferences for working in flexible occupations over cohorts, so that women in recent cohorts had preferences that made them about 15% more likely to be working

[11]Under a multinomial logit specification, relative probabilities (or relative risk ratios) can be calculated using the *odds* of the estimated preference parameters for working in occupations (O_{occ}), which are equal to the exponents of these estimated coefficients. Since the change in the probability of working in the occupation (p_{occ}) associated with a particular coefficient and its odds (relative to the base category of home production) can be estimated as the ratio $p_{occ} = \frac{O_{occ}}{1+O_{occ}}$, the relative probability (or relative risk) of working in flexible (vs. inflexible) occupations is the ratio of the probability of working in flexible occupations to inflexible occupations. For instance, Figure 12a plots the change in the probability of working in flexible occupations (compared to the probability of working in inflexible occupations) that is associated with changes in cohort-specific preferences over time. Table 6 reports the estimates of the cohort-specific preferences (or the log odds of these preferences) for women for flexible occupations as -0.17 and for inflexible occupations as 0.72 in the 1990s. The odds of working in these occupations associated with these preferences, relative to home production, are the exponents of these values: 0.84 for flexible occupations and 2.05 for inflexible occupations. Therefore, the probabilities of working in these occupations (as opposed to home production) as a result of these preferences, are $0.45 = 0.84/(1 + 0.84)$ for flexible occupations and $0.67 = 2.05/(1 + 2.05)$ for inflexible occupations. Therefore, the relative probability (or relative risk ratio) of working in flexible (compared to inflexible) occupations in the 1990s due to differences in preferences is 0.67, and similarly, this relative probability associated with cohort-specific preferences in the 2010s can be calculated as 0.81, so that the change in the relative probability of working in flexible occupations between the 1990s and 2010s is 0.14, which can be seen in Figure 12a.

in flexible occupations (versus inflexible occupations) compared to those in earlier cohorts. Conversely, the relative preferences for working in flexible occupations did not increase women's probability of working in these occupations substantially over the life cycle, as seen in Figure 12b. Figure 3 showed earlier that the share of women working in flexible occupations increased slightly over the life cycle, but that there were more substantial increases in this share across cohorts, where the estimates of the preference parameters discussed here suggest that large increases in women's relative preferences for working in flexible occupations over time in particular have been driving these observed patterns of increases in the share of women working in flexible occupations across cohorts. It may be that women's preferences for flexibility are not very important for changing their occupational choice decisions over the life cycle if they have already taken into account their future family and fertility preferences when making their initial career choices and have therefore internalised any anticipated future costs at the start of their career (Adda et al., 2017).

A related literature has suggested that cultural factors play an important role in changing women's labour market attachment over time as increases in female employment (either in formative periods such as childhood and adolescence, or driven by neighbourhood peer effects due to exogenous changes such as migration) are likely to cause changes in beliefs related to working (and reduce the stigma associated with working motherhood) (Fernandez et al., 2004; Fernández, 2013; Fogli and Veldkamp, 2011; Miho et al., 2019; Boelmann et al., 2020; Schmitz and Weinhardt, 2019; Maurin and Moschion, 2009; Olivetti et al., 2020). This suggests that as flexible working became more widespread among working women, even so that legislation such as the Right to Request Flexible Working came into place in June 2014, women were able to increasingly demand this amenity and if willing, to sacrifice pay in order to be able to make use of it (Mas and Pallais, 2017; Bustelo et al., 2020). Differences in culture around childcare and domestic responsibilities are often enhanced by insitutional and policy settings that encourage different norms of behaviour around working after parenthood – in many developed countries, though men's childcare and domestic work hours have increased over time, this has not translated to changes in women's time use patterns (Altintas and Sullivan, 2017; OECD, 2019; Sayer, 2016). Furthermore, Andresen and Nix (2019) find that while Norwegian women in heterosexual and adopting couples experience similar motherhood penalties, birth mothers in same sex couples experience larger penalties relative to the other partner but catch up within two years of childbirth, suggesting that child penalties are largely driven by gender norms and differences in preferences for childcare.

On the other hand, changes to women's preferences for working in flexible occupations over time may arise due to changes in the costs of motherhood over time, as policies related to and availability of formal and informal childcare change Kuziemko et al. (2018). In the UK, the increase in childcare costs outstripped the increase in wages by about three to four times overall between 2008 and 2016(Reland, 2017a,b). Importantly, though Albanesi and Olivetti (2016) found that improvements in infant formula reduced constraints on women's labour force participation related to breastfeeding, recent medical advice has encouraged mothers to exclusively breastfeed infants for at least six months and discourages infant formula in comparison (Cortés and Pan, 2020). Though the UK has some of the lowest breastfeeding rates in the world, with eight out of ten women stopping breastfeeding before they want to, these rates have steadily increased over recent decades (UNICEF, 2021; NCT, 2000, 2012).

These unexpected costs of motherhood may also be related to increases in the value of childcare time as returns to human capital have increased. Browning et al. (2013) documents that though women's time spent on chores has fallen significantly in recent years, their time spent with children has increased substantially (with men also spending more time with their children than previously). For instance, educated women in particular are likely to favour high levels of investment in children, and this has reinforced patterns of assortative mating (amnog white couples in the US) as the primary returns to marriage have shifted towards human capital investments (Chiappori et al., 2017; Lundberg and Pollak, 2014; Lundberg et al., 2016). These increased investments in children's human capital through both increased child-related expenditure and childcare time have been concentrated among college graduates, so that constraints related to flexibility may be even more binding for college-educated women as though they work more hours, they have also spent increasingly more time with their children compared to their less educated counterparts (Altintas, 2016; Altintas and Sullivan, 2017; Guryan et al., 2008). Borra and Sevilla (2019) document for the UK that the time that highly educated parents spent with children rose as there was increased competition for university places in the 1980s and early 1990s (mirroring US findings by Ramey and Ramey (2010)). Doepke and Zilibotti (2017) support this hypothesis, suggesting that increases in wage inequality are associated with increases in returns to education and with more intensive styles of parenting, both across countries, and over time for the US. In the UK, as the proportion of cohorts in higher education increased, the wage premium for a 'good' degree also increased over time (Naylor et al., 2016).

Figure 13 shows that there was indeed a large increase in the share of graduates over the analysis period, which coincided with this period of widening participation in higher education in the UK. As the share of graduates in cohorts increased over time, this may have led to recent cohorts of graduates being composed of lower skills admissions than previously, causing greater wage dispersion among graduates, and a weakening of graduate status as a signal for ability (Green and Henseke, 2016; Walker and Zhu, 2008, 2011). The increase in the share of graduates over cohorts may therefore have had a compositional effect on the preferences for flexibility. It may be that the composition of the graduate labour force changed so that preferences for flexibility became more important, rather than a general overall increase in preferences for flexibility among highly skilled graduates (comparable to the earliest cohorts). Figure 13 shows that while less than 20% of women in the survey had college degrees in 1993, this figure had increased to about 46% by 2017. Similarly, the share of men with college degrees increased from 23% to 41% between 1993 and 2017. Therefore, it may be that college education in the past was reserved to more highly motivated individuals who were able to capture high-paying jobs that may have been inflexible in nature. However, as graduate degrees became more common, women who went to university may not only have been those who were career-oriented and therefore, the preferences for flexibility among graduates themselves may have increased naturally as a result of this.

Figure 12a shows that on average, changes to men's preferences for working in occupations did not result in changes in the relative probability of men working in flexible occupations across cohorts, which agrees with the patterns in the data. Moreover, as Figure 12b shows, changes in preferences did not lead to a substantial change in the relative probability of working in flexible occupations over the life cycle for men. This suggests that life cycle changes to preferences for working in flexible and inflexible occupations did not account for the reduction in the share of men working in flexible occupations at older ages (seen in Figure 3), and instead, the increase in men's likelihood to be working in inflexible occupations after life events, particularly as a result of the increases in fertility in more recent cohorts (as discussed earlier), may be behind these patterns.

Robustness checks of the supply side of the model are presented in Appendix

B and are in line with the main patterns in the results discussed here.

5.3 Counterfactual Exercises

We have so far discussed the estimated effects of various demand- and supply-side factors on the gender wage gap and occupation flexibility, and how they relate to the trends observed in the data. This section discusses how the outcomes of interest would have changed had the parameters driving these trends been different by comparing the estimated model with counterfactual simulations. This allows us to consider how changes to specific factors, keeping all other factors constant, affect the wage and labour supply outcomes of interest.

Table 7 presents estimates summarising changes in the main outcomes of interest over the life cycle and over time for the original data, model predictions, as well as counterfactual predictions under alternative scenarios. From Column (1), on average the gender age gap increased by 24.3 log points over the life cycle (across all years of the sample), with a smaller increase over time of 0.7 log points on average. The share of men working in flexible occupations fell over the life cycle by about 5.3 percentage points on average across all years, whereas the share of women working in flexible occupations fell over the life cycle by 5.6 percentage points on average across all years – averaging across all years flattens out the life cycle fall for women. On the other hand, the share of men working in flexible occupations fell over time (across all cohorts) by about 4.6 percentage points on average, while the share of women working in flexible occupations increased over time at 5.6 percentage points. Furthermore, the flexibility wage penalty increased over the life cycle by about 13.7 log points on average, and over time by about 1.6 log points on average. Column (2) presents estimates of these changes in earnings ratios and share working in flexible occupations as predicted by the model, in comparison to the observed data, showing that the model captures the general nature of the patterns, though it avoids flattening out the patterns by averaging across cohorts or over ages, resulting in underestimates of most of the outcomes except for the changes in the gender wage gap and the share of women working in flexible occupations over time.[12]

The counterfactual estimates in Column (CF1) are obtained by fixing the demand shares for men and women conditional on gender and occupation ($\alpha_{2,a,o,s}$) to remain

[12]The estimates of the change in the gender wage gap and flexibility wage penalty and share working in flexible occupations are presented differently in the counterfactual estimates compared to how they are actually in the model and the raw data. While the model is estimated at the level of cohorts and age groups, the estimates are presented as the difference over the working life cycle between ages 25 and 55 and over time between 1993 and 2017 – averaging the changes across all years and over all ages, respectively. This makes some of the patterns in the estimates different to what has been discussed earlier.

constant at the level of the demand shares for labour aged 25-34 years, over the life cycle. Figure 9a showed that the relative demand for men increased over ages in both flexible and inflexible occupations, so this counterfactual scenario highlights how this change in the relative demand for men at older ages contributed to the life cycle patterns in the outcomes of interest. The counterfactual estimates in column (CF1) of Table 7 show that without these increases in relative demand for male labour in both occupation types over ages, the life-cycle increase in the gender gap would have fallen close to zero. This suggests that despite the initial small disparity in wages for graduate men and women upon labour market entry, further increases in relative demand for male labour at older ages were a key driver behind the increase in the gender wage gap over the life cycle. Furthermore, the life cycle increase in the wage penalty from working in flexible occupations would also have reduced close to zero in the absence of these increases in relative demand for male labour in both flexible and inflexible occupations.

In Column (CF2) of Table 7, supply-side male and female preferences for working in flexible and inflexible occupations are assumed fixed over the life cycle at the levels in the 1990s over the sample period ($\psi_{0,s,c,j} = \psi_{0,s,90s,j}$). Figure 12 showed that the changes in men's and women's preferences for working in flexible and inflexible occupations over time was a major factor contributing to changes in the probability of working in these occupations over time. Counterfactual (CF2) therefore highlights how the outcomes of interest would have changed over time had cohort-specific preferences for working in occupations not changed over time. Column (CF2) of Table 7 shows that if preferences for occupation flexibility had remained at the level of the 1990s, the increase in the gender wage gap over time would have been much smaller at about 0.7 log points, compared to an increase of 3.2 log points as predicted by the model. This would have largely been driven by the much smaller increase in the share of women working in flexible occupations over time, while the share of men working in flexible occupations would have increased over time under this scenario. This would have also meant that there would have been smaller increases in the wage penalty from working in flexible occupations both over time and over the life cycle.

Similarly, in the next counterfactual scenario (CF3), male and female age-specific preferences for working in flexible and inflexible occupations are assumed to have remained at the level for the 25-34 age group over the life cycle ($\psi_{0,s,a,j} = \psi_{0,s,25-34,j}$). Column (CF3) of Table 7 shows that keeping preferences for working in occupations fixed at the level of the 25-34 age group would have resulted in slightly smaller increases in the gender wage gap over the life cycle and across cohorts, in comparison to the contributions of the increase in cohort-specific preferences for flexibility. This would have been because of smaller reductions in the share of men working in flexible occupations over the life cycle, whereas the reduction in the share of women working in flexible occupations over the life cycle would have been larger, while there would have been a slightly smaller increase in the share of women working in flexible occupations over time. This would have also contributed to smaller increases in the flexibility wage penalty over time and over ages.

In Columns (CF4) and (CF5), the gender- and age-specific rates of fertility and marriage, respectively, are assumed to remain at 1993 levels throughout the sample period (i.e. $Pr(\text{child} < 5 = 1 \mid s, a, t) = Pr(\text{child} < 5 = 1 \mid s, a, 1993)$ and $Pr(\text{marr} = 1 \mid s, a, t) = Pr(\text{marr} = 1 \mid s, a, 1993)$). Column (CF4) shows that if fertility rates among graduates had not increased as seen in Table 5, the gender wage gap would have increased slightly over time (compared to the original prediction), as the share of women working in flexible occupations would have increased over time (as well as over the life cycle by a smaller amount), whereas the share of men working in flexible occupations would have reduced by a smaller amount over time. This would also have contributed to a larger increase in the wage penalty from working in flexible occupations over time. The counterfactual estimates in Column (CF5) show that in the absence of the reduction in marriage rates, both the reduction in the share of women working in flexible occupations over the life cycle and the increase in this share over time would be slightly smaller. There would also have been a smaller life cycle reduction in the share of men working in flexible occupations, while the reduction in the share of men working in flexible occupations over time would have been larger. The absence of the reduction in marriage rates would have therefore contributed to a smaller increase in the flexibility wage penalty over time.

In Columns (CF6) and (CF7), child-related benefits are assumed to remain at 1993 levels ($CBEN_{a,t} = CBEN_{1993,t}$) and childcare costs at zero ($CHC_{a,t} = 0$), respectively, throughout the sample period. The estimates in Column (CF6) reinforce findings by Kleven et al. (2020) that changes to family policies such as childcare subsidies and maternity leave contributed very little to changing the gender wage gap as we find that they had very little impact on the share of women working in flexible occupations, though they did contribute to reducing the flexibility wage penalty over time. The estimates in Column (CF7) show that under a counterfactual scenario where childcare costs were assumed to stay at zero over the sample period, there would have been only a small reduction in the gender wage gap over both time and the life cycle, whereas the share of women working in flexible occupations would have reduced by a slightly larger amount over the life cycle and increased by a smaller amount over time.

6 Conclusion

This paper estimates a model of labour supply and demand in order to evaluate the importance of occupation flexibility for changes to the gender wage gap over the life cycle and over time for the graduate workforce in the UK. We define flexibility as a characteristic of occupations as in Goldin (2014), such that firms substitute between labour in flexible and inflexible occupations on the demand side, and individuals make occupational choice decisions based on their preferences for flexibility on the labour supply side.

Our estimates show that increases in relative demand for male labour (versus female labour), and in inflexible occupations, mainly contributed to the increase in the gender wage gap over the life cycle, with the increase in this relative demand (and the gender wage gap) especially pronounced till about age 40. Furthermore, changes to women's preferences so that more recent cohorts of women were more likely to choose to work in flexible occupations contributed to the large increase in the share of women working in flexible occupations over time, as well as a large proportion of the increase in the flexibility wage penalty and to increasing the gender wage gap over time. We also find that the higher relative demand for inflexible occupations (for both men and women) at older ages and over time contributed to increases in the wage penalty from working in flexible occupations, and therefore to increased gender wage disparity.

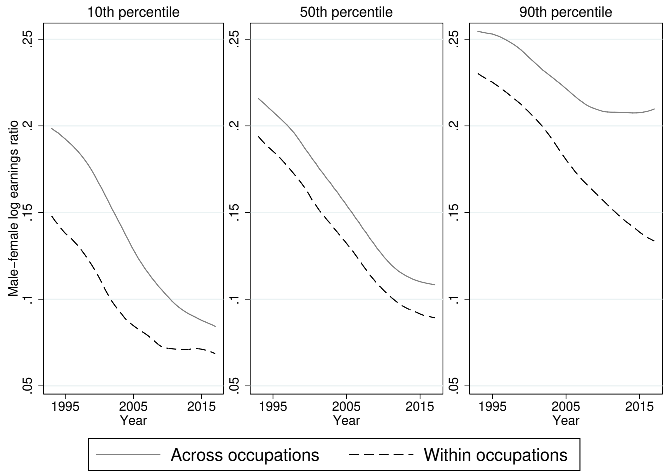
The estimates presented here also show that fertility and marriage are both negatively associated with female labour supply, supporting existing research that women's preferences for flexibility contribute to changes to women's working patterns and an expansion of the gender wage gap over the life cycle. However, the fact that these preferences have increased over time is less well established, and this increase in women's preferences for flexibility over cohorts, has been concurrent with an increase in the wage premium to working inflexibly (working long hours or overworking) over time. The increased returns to overworking have been especially pronounced in highly paid occupations, which has prevented women from closing the wage gap especially at the top of the earnings distribution (Bertrand, 2018; Cha, 2010; Cha and Weeden, 2014). Bertrand et al. (2019) found that gender quotas for company boards had limited positive impact on the overall labour market outcomes of women employed in such firms in Norway, beyond the increase in the earnings for women directly appointed to these boards, suggesting that there is limited potential for gender quotas to break the glass ceiling, so that policy measures to promote flexibility in higher-paid occupations may be an alternative solution. Unlike with women, men were likely to reduce their participation in flexible occupations and increase it in inflexible occupations after marriage, also seen in the descriptive trends as graduate men in the UK were likely to move out of flexible occupations and into inflexible occupations at older ages. Finally, increased childcare costs were associated with women reducing their participation in both flexible and inflexible occupations, whereas increased tax credits and benefits related to childcare did not significantly affect graduate women's participation in the labour market, as has been documented elsewhere (Blundell et al., 2016; Kleven et al., 2020).

7 Figures and Tables

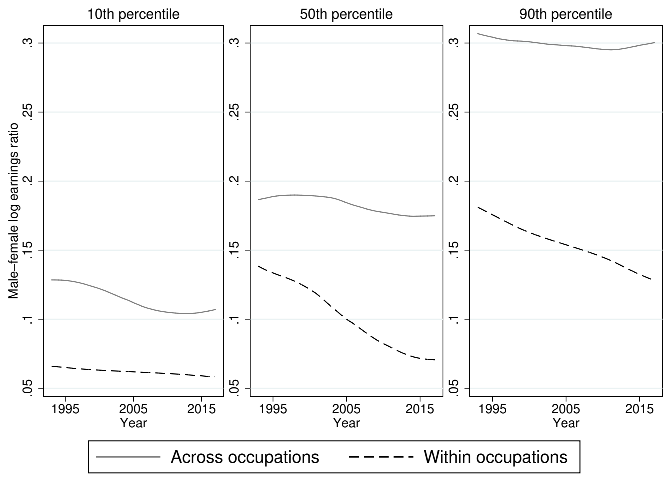
7.1 Figures

Figure 1: The gender wage gap within and across occupations, across the distribution over time

(a) Overall gap in earnings for full-time employees



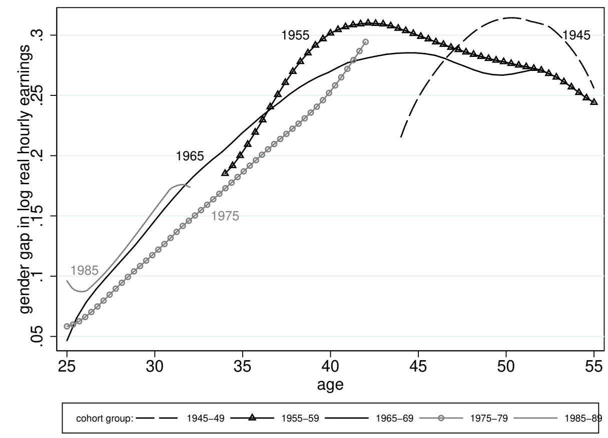
(b) Gap in earnings for graduate full-time employees



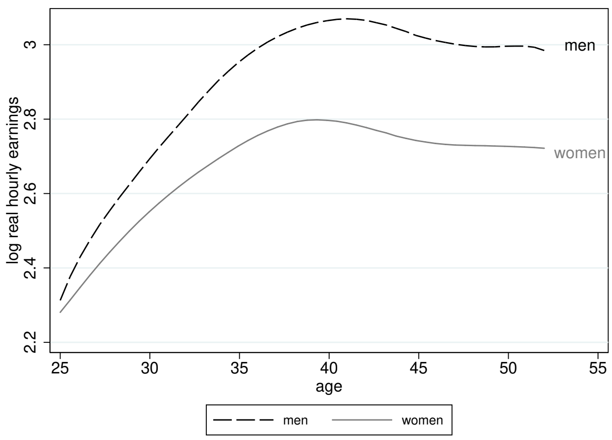
Notes: The graphs plot the difference between log male and female real hourly earnings at different percentiles of the earnings distribution, both within and across occupations - panel (a) for all full-time workers, and panel (b) for graduate full-time workers. The plotted lines are smoothed local polynomials of degree 0.

Figure 2: Gender wage gap for graduates, by cohort, over the life cycle

(a) Gender wage gap by cohort

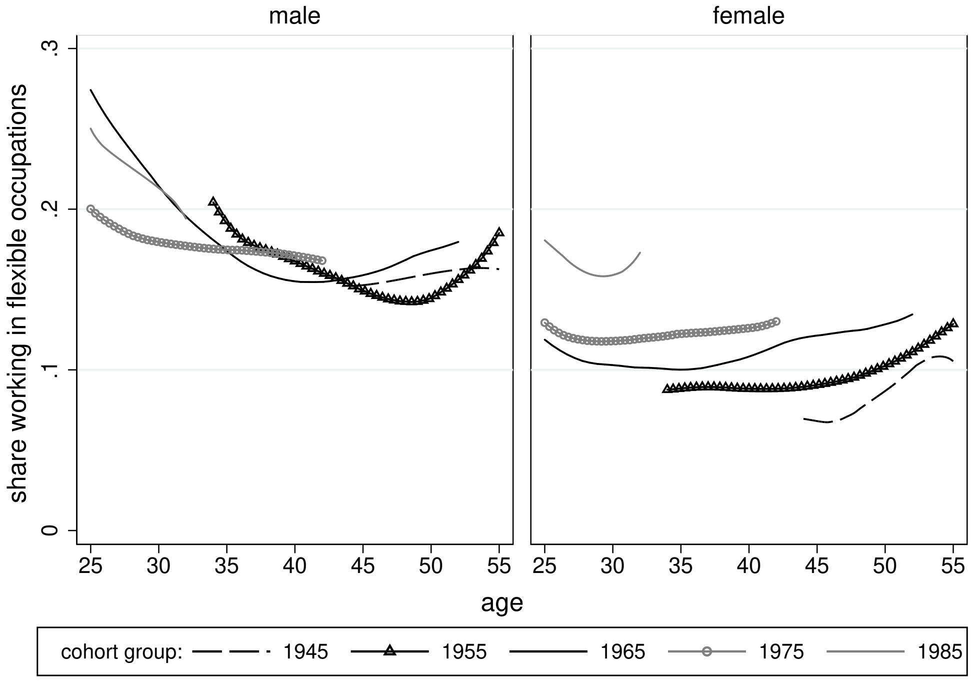


(b) Male and female wages over the life cycle for cohort born 1965-69



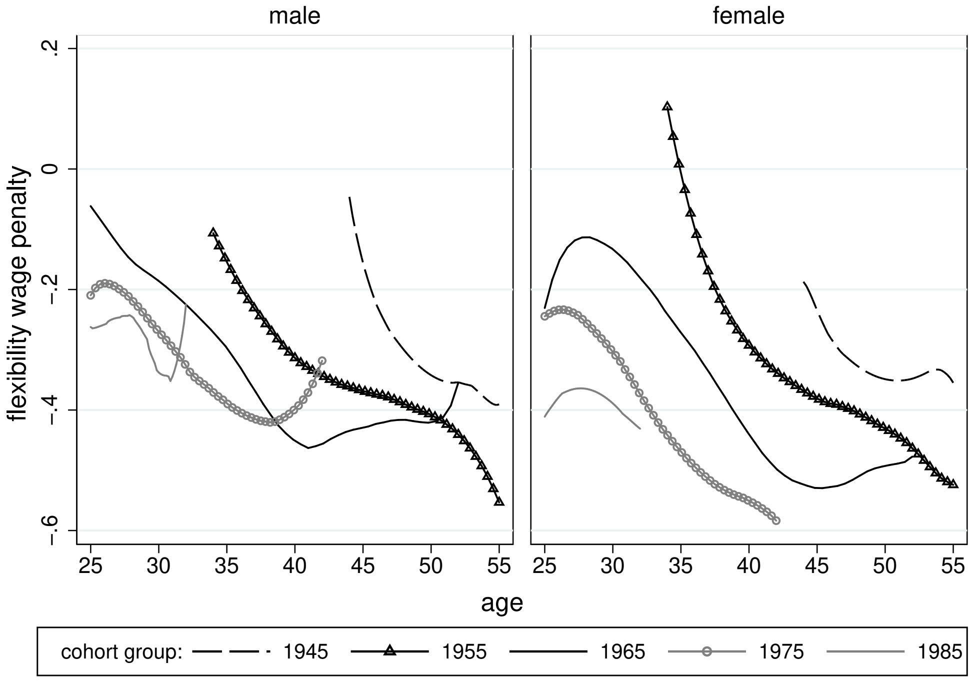
Notes: The graph in panel (a) plots the difference between log male and female real hourly earnings for different cohorts between ages 25 and 55. The graph in panel (b) plots the evolution of log real hourly earnings between ages 25 and 52 for men and women born between 1965 and 1969. The plotted lines are smoothed local polynomials of degree 2. Cohort groups comprise of the cohorts of individuals born in the five years starting from the specified year, i.e. cohort group 1945 comprises of all individuals born from 1945-1949.

Figure 3: Share of graduates working in flexible occupations by cohort, over the life cycle



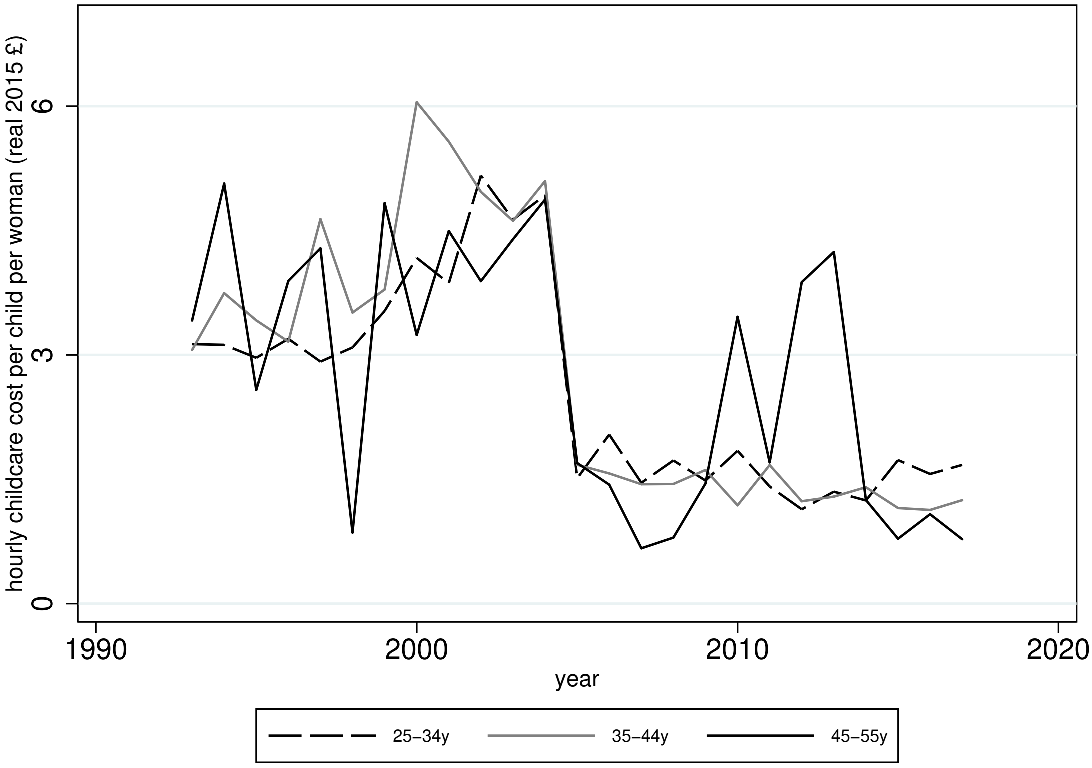
Notes: The graphs plot the share of male and female graduates working in flexible occupations, as defined by a binary indicator, across different cohorts between ages 25 and 55. The binary indicator defines flexible occupations as those that have a flexibility score above the median for all occupations. The plotted lines are smoothed local polynomials of degree 2. Cohort groups comprise of the cohorts of individuals born in the five years starting from the specified year, i.e. cohort group 1945 comprises of all individuals born from 1945-1949.

Figure 4: Flexibility wage penalty for graduates by cohort, over the life cycle



Notes: The graph plots the evolution of the wage penalty associated with a 1SD increase in occupation flexibility score between ages 25 and 55, separately for male and female graduates in different cohorts. The plotted lines are smoothed local polynomials of degree 2. Cohort groups comprise of the cohorts of individuals born in the five years starting from the specified year, i.e. cohort group 1945 comprises of all individuals born from 1945-1949.

Figure 5: Childcare Costs over Time

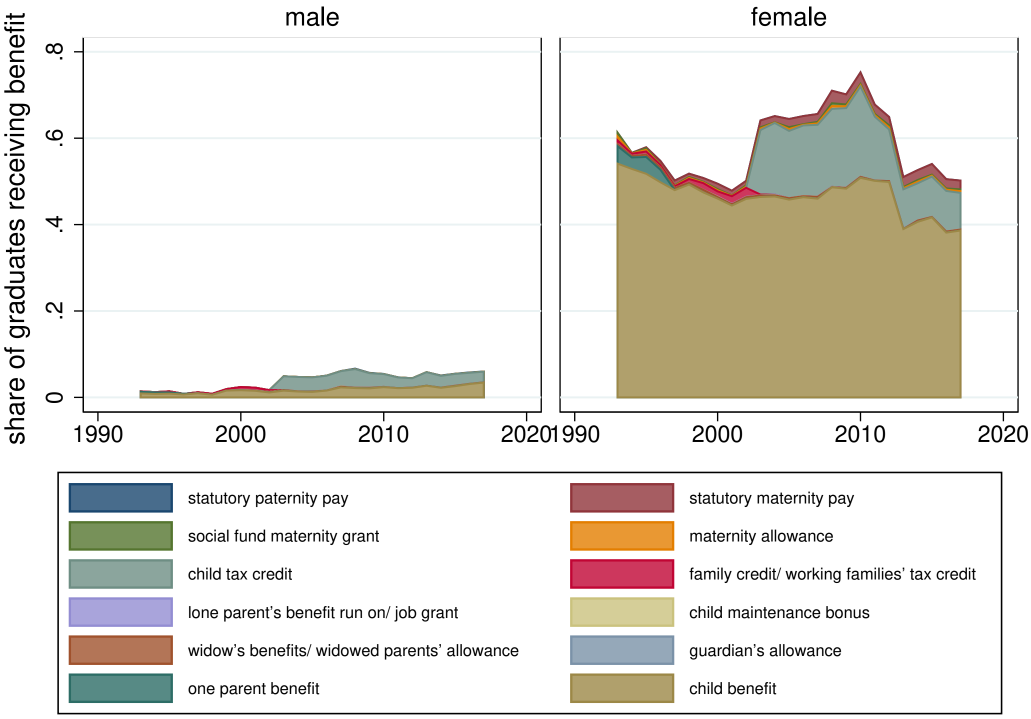


Source: Family Resources Survey.

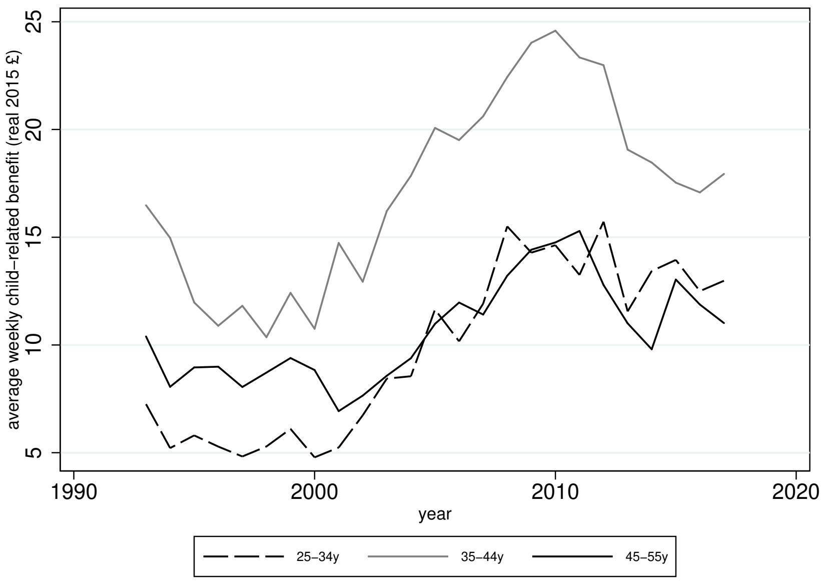
Notes: This graph plots the change over time in the average childcare costs per child in the household for women in the Family Resources Survey, in real 2015 £.

Figure 6: Child-Related Benefits Over Time

(a) Share of Graduates Receiving Child-Related Benefits



(b) Weekly Child-Related Benefit

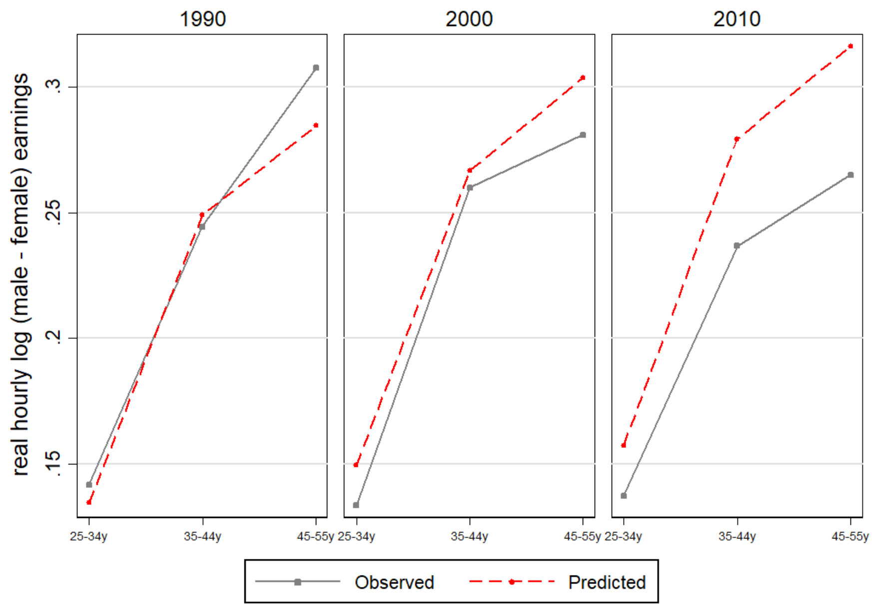


Source: Family Resources Survey.

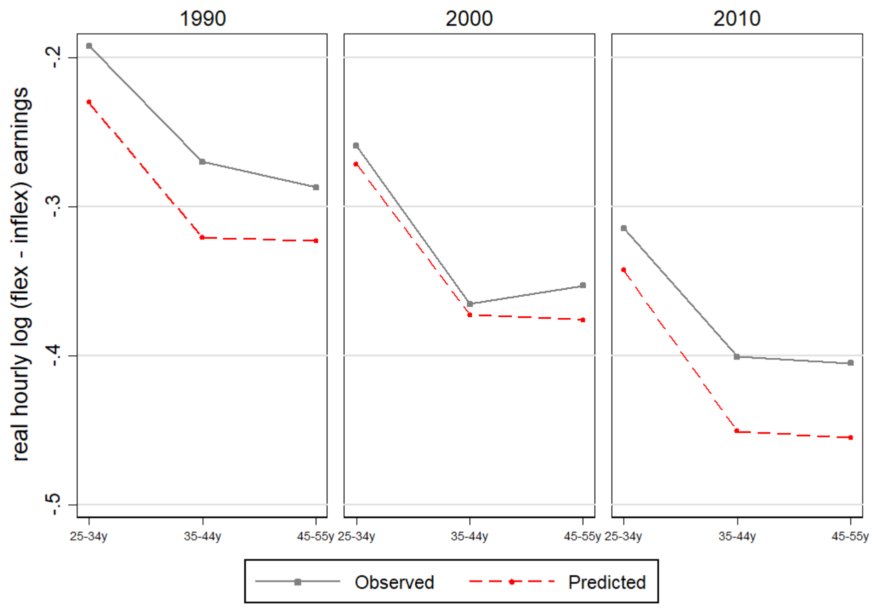
Notes: The graph in panel (a) plots the share of graduate men and women receiving child-related benefits over time. The graph in panel (b) plots the average child-related benefits received by women over time, in real 2015 £.

Figure 7: Data and Model Predictions for the Gender Wage Gap and the Flexibility Wage Penalty, By Cohort and Age Group

(a) Log (male-female) hourly earnings gap



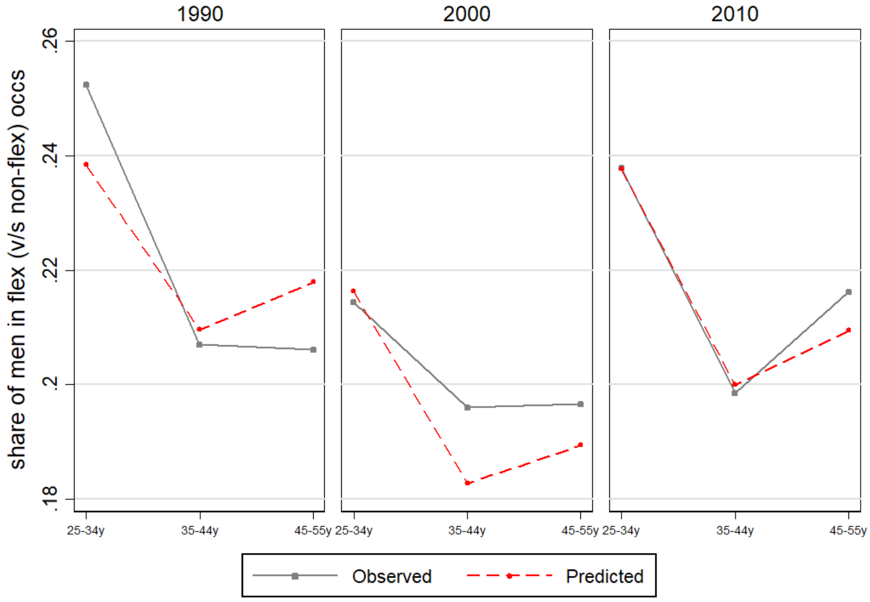
(b) Log (flexible-inflexible) wage penalty



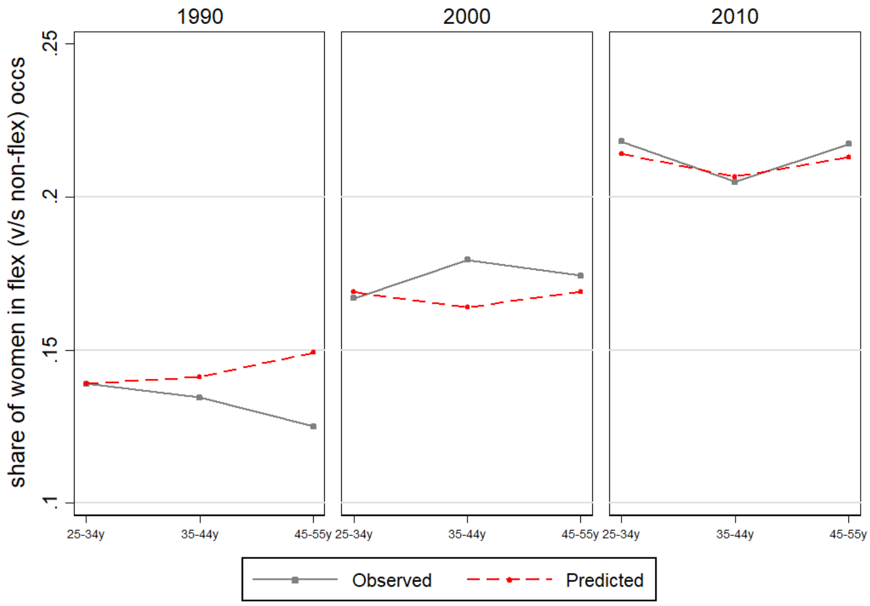
Notes: These graphs plot the trends in the outcomes of interest related to earnings (the male-female gender wage gap and the wage penalty from working in flexible occupations (relative to inflexible occupations), for the age groups and cohorts used in the model, both as observed in the data and predicted from the model.

Figure 8: Data and Model Predictions for the Share in Flexible Occupations, By Cohort and Age Group

(a) % men in flexible occupations



(b) % women in flexible occupations

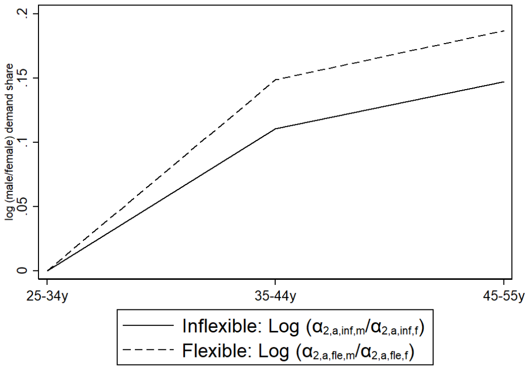


Notes: These graphs plot the trends in the outcomes of interest related to labour supply (the share of men and women working in flexible occupations (versus inflexible occupations)) for the age groups and cohorts used in the model, both as observed in the data and predicted from the model.

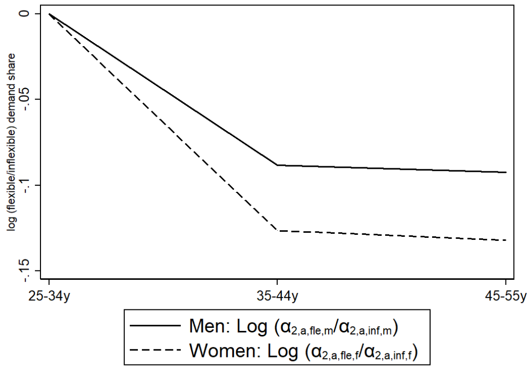
Figure 9: Estimates of Relative Demand Shares and Total Factor Productivity

Production Technology: Nest II

(a) Male vs. Female

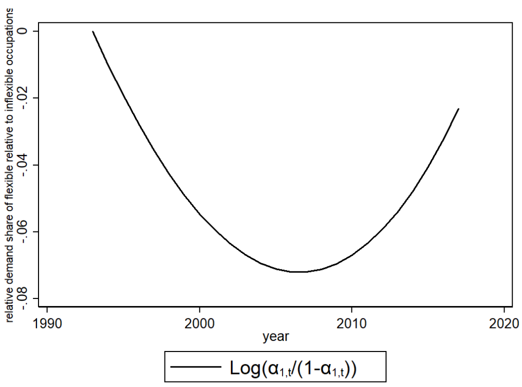


(b) Flexible vs. Inflexible

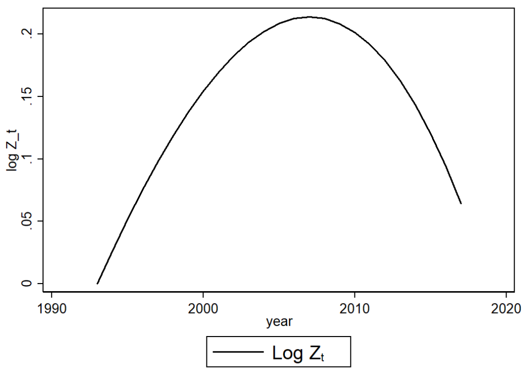


Production Technology: Nest I

(c) Flexible vs. Inflexible

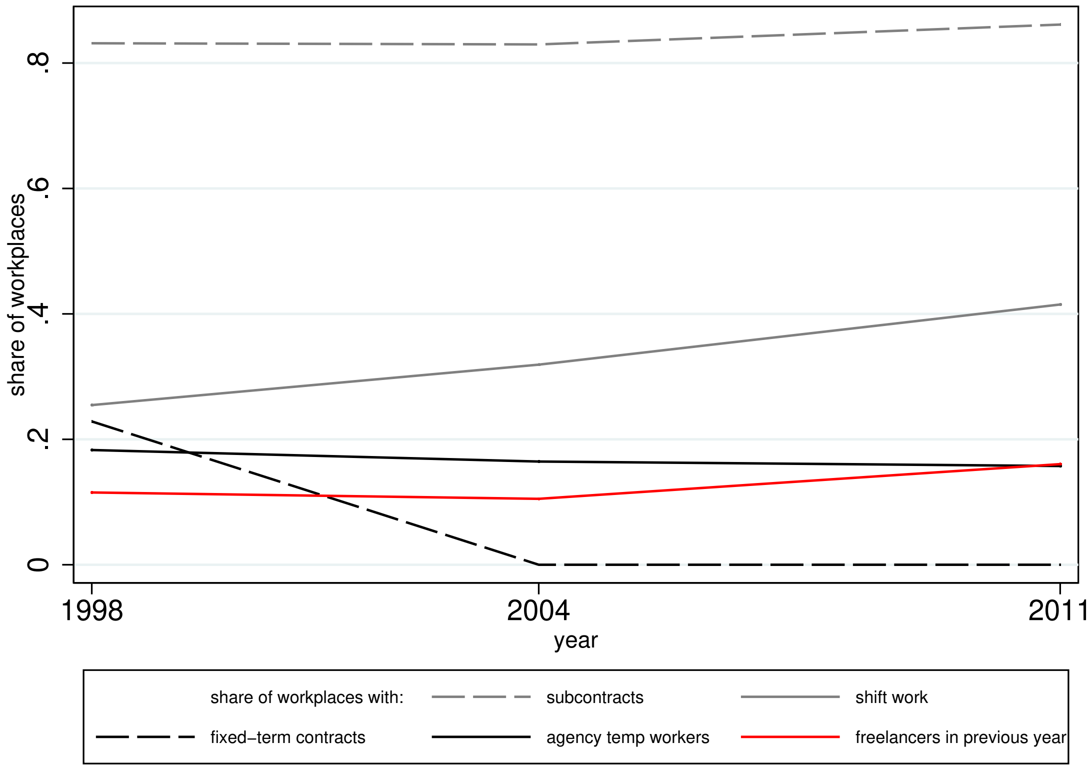


(d) Total Factor Productivity



Notes: These graphs plot the relative demand shares and total factor productivity estimated by the model. The relative demand shares, plotted in panels (a)–(c), are the log ratios of the demand shares for each labour type. The demand shares in the second nest of the production function are fixed over time (panels (a) and (b), and vary over age. The demand share (panel (c)) and total factor productivity (panel (d)) in the first nest of the production function are the natural logarithms of quadratic time trends. Each series is normalised to zero in 1993 for ease of interpretation.

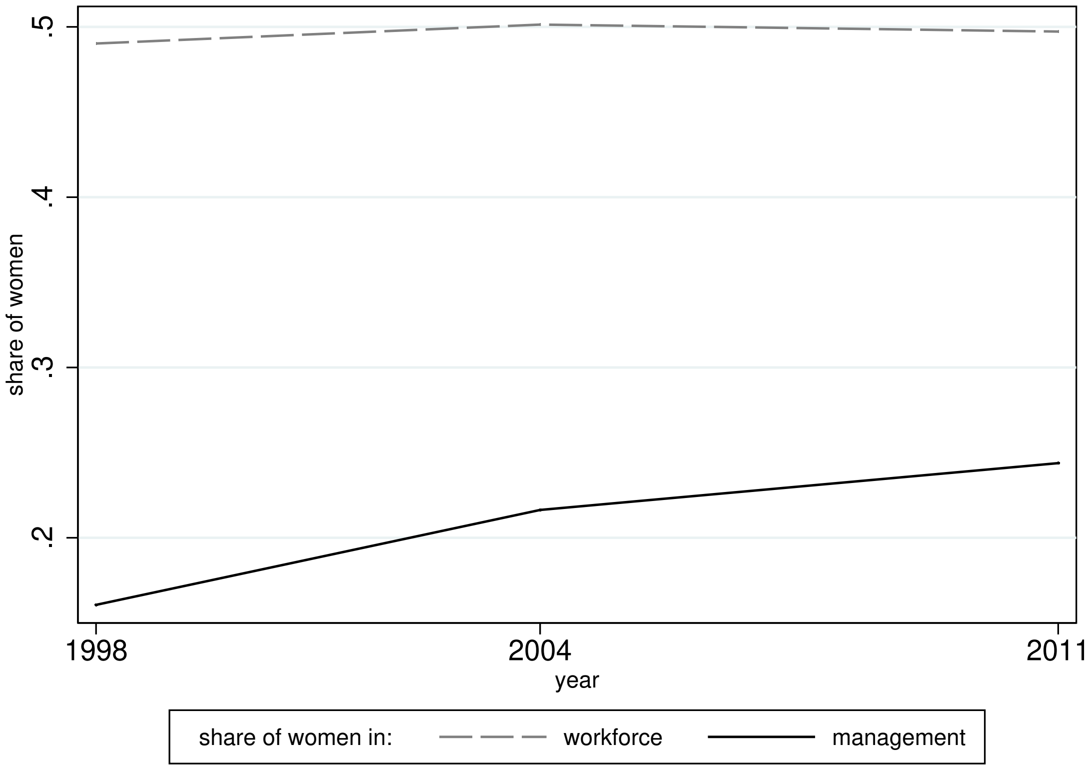
Figure 10: Share of Workplaces with Flexible Working Arrangements



Source: Workplace Employment Relations Survey, Time Series Dataset: 1998, 2004, 2011.

Notes: This graph plots the share of workplaces wih 10 or more employees sampled in the Workplace Employment Relations Survey that have employees hired under flexible working arangements of different types.

Figure 11: Share of Women in Workplaces Over Time

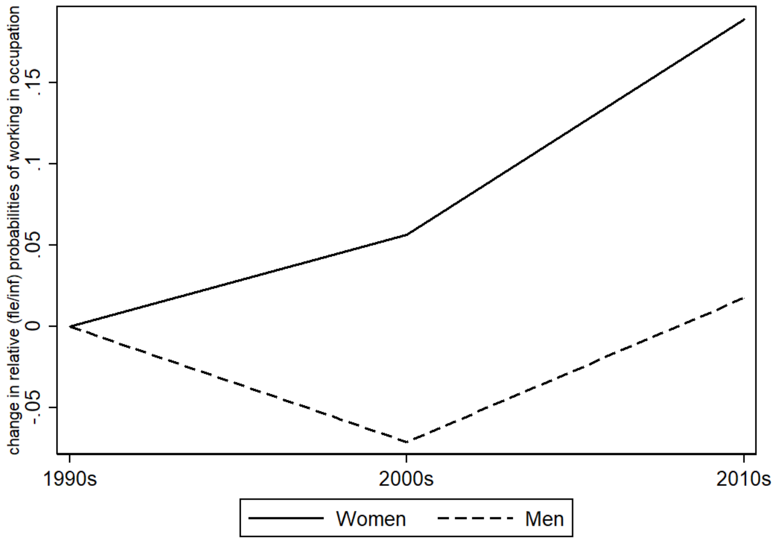


Source: Workplace Employment Relations Survey, Time Series Dataset: 1998, 2004, 2011.

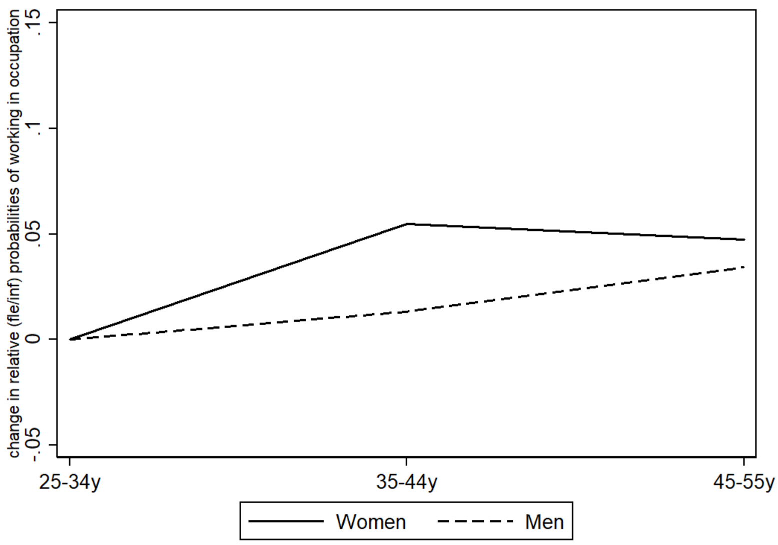
Notes: This graph plots the share of women in the workplace and in management positions in the sample of firms with 10 or more employees surveyed by the Workplace Employment Relations Survey.

Figure 12: Estimates of Changes in Relative Probabilities of Working in Flexible Occupations Over the Life Cycle and Time

(a) Cohort-Specific Preferences, Fixed over Ages

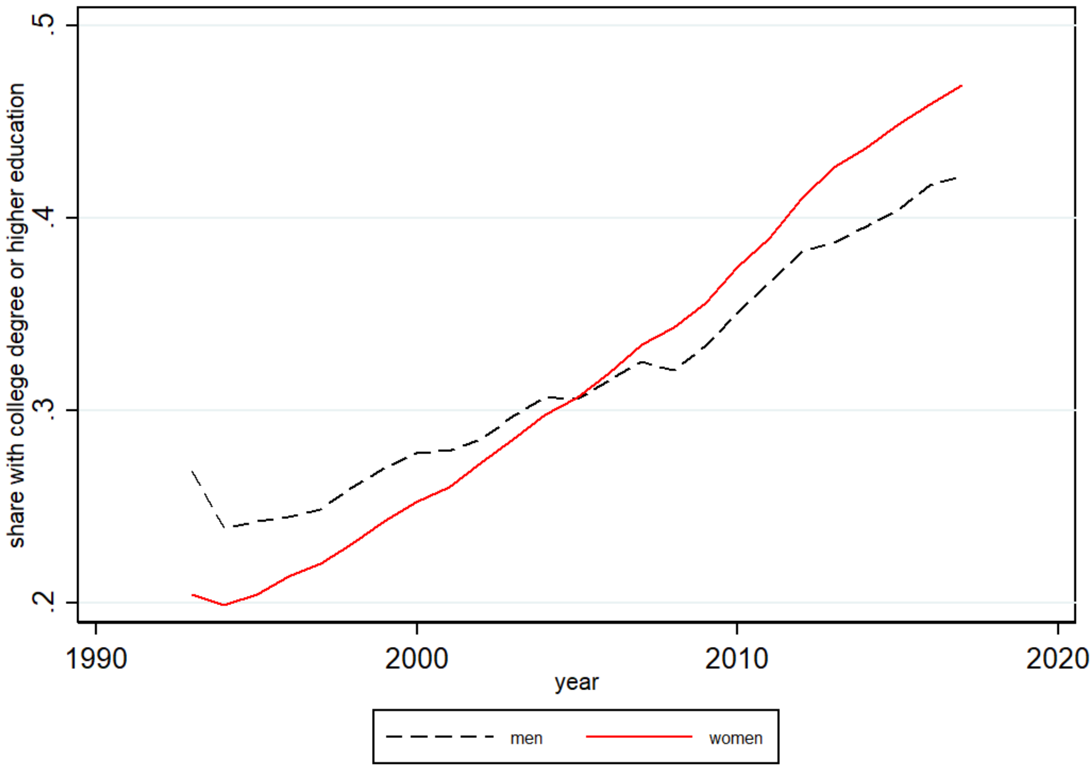


(b) Age-Specific Preferences, Fixed over Time



Notes: These graphs plot the changes in the relative probabilities of working in flexible occupations (compared to inflexible occupations) given the changes in specified preference parameters, keeping all else constant. The estimates in panel (a) plot the changes in the relative risk of working in flexible occupations for men and women over time, compared to the 1990s, following the evolution of the cohort-, gender-specific preference parameters for working in occupations that are fixed over ages ($\psi_{0,s,c,j}$). The estimates in panel (b) plot the changes in the the relative probability of working in flexible occupations for men and women over the life cycle, compared to age 25-34, following the evolution of the age-, gender-specific preference parameters for working in occupations that are fixed over time ($\psi_{0,s,a,j}$).

Figure 13: Graduate Share of Men and Women Over Time



Notes: These graphs plot the share of men and women in the Labour Force Force Survey who had a college degree, i.e. who then formed the sample for analysis over time.

7.2 Tables

Table 1: Flexibility and occupation characteristics in minor occupation groups for graduates between 2001 and 2010

Rank	SOC2000 3 digit	Occupation group title	Flexibility score [average]	Time pressure	Contact with others	Interpersonal relationships	Structured work	Decision making freedom	Occupation share of graduates (%)	Male share of occupation graduates (%)	Share working part-time (%)
Least flexible occupations											
81	221	Health professionals	-0.87	0.02	-0.87	-0.96	-1.14	-1.20	3.35	51.4	16.0
80	354	Sales & related associate professionals	-0.81	-0.16	-0.87	-0.85	-1.22	-0.69	1.83	52.4	9.3
79	244	Public service professionals	-0.72	-0.36	-1.02	-1.01	-0.54	-0.55	1.58	38.9	13.9
78	122	Managers & proprietors in hospitality & leisure services	-0.62	-0.63	-0.87	-0.37	-0.68	-0.44	0.88	57.6	8.1
77	116	Managers in distribution, storage, and retailing	-0.59	-0.95	-0.56	-0.58	-0.56	-0.27	1.32	71.5	5.3
76	115	Financial institution and office managers	-0.54	-0.47	-0.50	-0.88	-0.43	-0.40	1.71	50.7	8.8
75	123	Managers and proprietors in other service industries	-0.53	-0.42	-0.50	-0.91	-0.52	-0.40	1.71	58.9	10.9
74	112	Production managers	-0.52	-0.22	-0.39	-0.81	-0.52	-0.65	3.08	89.8	2.1
73	113	Functional managers	-0.51	-0.22	-0.56	-0.88	-0.68	-0.32	9.18	67.3	5.0
72	629	Personal services occupations n.e.c. (e.g. undertakers)	-0.50	-0.67	-0.04	-0.40	-0.89	-0.53	0.02	58.4	21.6
Most flexible occupations (employing at least 0.4% of graduate sample between 2001 and 2010)											
3	922	Elementary personal services occupations (e.g. waitresses)	0.67	0.59	-0.17	0.46	1.14	0.61	0.42	40.6	52.9
17	612	Childcare & related personal services	0.26	1.70	0.00	0.28	-0.19	-0.48	2.07	6.1	54.3
22	323	Social welfare associate professionals	0.15	-0.95	-1.35	0.27	0.89	1.87	1.50	26.3	25.1
23	312	Draughtspersons & building inspectors	0.13	0.47	0.09	0.07	0.23	-0.23	0.43	84.3	5.3
24	212	Engineering professionals	0.11	0.55	0.57	-0.38	-0.14	-0.06	3.13	92.6	1.9
25	522	Metal machining, fitting & instrument making trades	0.11	-0.53	1.01	0.61	0.25	-0.25	0.47	98.0	1.4
26	311	Science & engineering technicians	0.10	0.47	0.09	0.07	0.06	-0.23	1.10	71.4	7.9
28	821	Transport drivers & operatives	0.06	-0.38	-0.39	0.47	0.56	0.36	0.50	89.7	16.8
29	243	Architects, town planners, surveyors	0.05	-0.14	0.27	-0.51	0.31	0.31	1.44	83.5	4.8
30	531	Construction trades	0.02	-0.55	-0.13	0.46	0.15	0.19	0.58	96.6	6.0
Most flexible occupations											
1	414	Administrative occupations: communications	1.42	1.57	-1.26	-0.05	4.04	2.79	0.11	36.3	16.0
2	924	Elementary security occupations	0.69	1.74	-0.47	0.46	0.81	0.95	0.25	66.4	31.9
3	922	Elementary personal services occupations	0.67	0.59	-0.17	0.46	1.14	0.61	0.42	40.6	52.9
4	813	Assemblers and routine operatives	0.62	-0.51	0.66	0.50	0.73	1.03	0.27	67.7	10.9
5	812	Plant and machine operatives	0.57	-0.38	0.22	0.50	0.73	0.52	0.12	94.6	1.7
6	912	Elementary construction occupations	0.55	0.04	-0.04	0.60	0.97	1.20	0.08	95.6	22.0
7	521	Metal forming, welding, and related trades	0.44	-0.51	0.22	1.04	0.93	0.99	0.07	95.8	1.4
8	532	Building trades	0.43	-0.22	0.53	0.95	0.23	0.27	0.09	89.6	10.9
9	543	Food preparation trades	0.42	-0.59	0.35	0.44	0.68	1.41	0.23	60.8	22.3
10	923	Elementary cleaning occupations	0.42	-0.24	0.57	0.95	0.52	0.44	0.21	37.0	61.5

Notes: The table describes the nature of the ten most and least flexible SOC2000 minor occupation groups in the prime-aged sample of graduates in the QLFS between 2001 and 2010. For each minor occupation group, listed in order of their standardised flexibility score, the median flexibility score as well as the median score in each of the five flexibility components are shown. The occupation share of graduates is the percentage of the graduates in the sample that are employed in the minor occupation group. The male share of occupation graduates shows the percentage of graduates working in the occupation group that are male, and the final column shows the percentage of graduates in the occupation group that work part-time.

Table 2: Parameter Estimates: Production Technology

	Estimate	SE	Implied Elasticity $\frac{1}{1-\rho}$
ρ_1: flexible, inflexible occupations	0.3337	(0.1072)	1.5008
ρ_2: age group, sex	0.9740	(0.0285)	38.4334

Notes: This table reports the estimates of the substitution parameters, with standard errors included in parentheses. Implied elasticities of substitution from the production technology are also reported.

Table 3: Changes in Relative Wages and Labour Supplies between 1993 and 2017

	1993		2017		Dif-in-dif Earnings	Dif-in-dif Labour Supply
	Δ Earnings	Δ Labour Supply	Δ Earnings	Δ Labour Supply		
Occupation						
Inflexible – flexible	0.3489	1.3162	0.3764	1.2823	-0.0275	0.0339
Gender						
Male – female	0.2851	0.3525	0.2386	-0.0302	0.0465	0.3827
Gender, occupation						
Male – female, inflexible	0.2363	0.1886	0.2326	-0.0298	0.0037	0.2184
Male – female, flexible	-0.0620	-0.8292	-0.1373	-1.3130	0.0753	0.4838
Gender, occupation, age group						
Male – female, inflexible						
25-34	0.1563	0.0811	0.1451	-0.7749	0.0112	0.8561
35-44	0.1955	0.2093	0.2621	-0.9195	-0.0667	1.1288
45-55	0.3309	0.3128	0.2661	-0.7961	0.0647	1.1088
Male – female, flexible						
25-34	-0.0489	-0.0462	-0.1129	-1.2272	0.0640	1.1810
35-44	-0.1219	-0.0168	-0.0884	-1.4126	-0.0335	1.3958
45-55	-0.0181	-0.0262	-0.1994	-1.3091	0.1814	1.2829

Notes: This table reports the differences and changes in relative wages and labour supplies aggregated over types of labour, between 1993 and 2017.

Table 4: Parameter Estimates: Occupational Choice, Fixed over Time

	Estimates	SE	Average Marginal Effects
Earnings			
ψ_1: Earnings	0.7549	(0.2209)	0.0119
Fertility			
$\pi_{2,f,inf}$: Female, inflexible	0.1230	(0.0456)	-0.0077
$\pi_{2,f,fle}$: Female, flexible	-0.5480	(0.0686)	-0.0163
$\pi_{2,m,inf}$: Male, inflexible	1.0232	(0.0226)	0.0182
$\pi_{2,m,fle}$: Male, flexible	0.8260	(0.0249)	0.0147
Marriage			
$\pi_{3,f,inf}$: Female, inflexible	-0.0452	(0.0174)	-0.0006
$\pi_{3,f,fle}$: Female, flexible	-0.3263	(0.0197)	-0.0044
$\pi_{3,m,inf}$: Male, inflexible	0.5212	(0.0208)	0.0093
$\pi_{3,m,fle}$: Male, flexible	0.2372	(0.0225)	0.0042
Childcare costs			
$\gamma_{1,inf}$: Female, inflexible	-0.2213	(0.0065)	-0.0006
$\gamma_{1,fle}$: Female, flexible	-0.3860	(0.0114)	-0.0010
Child-related benefits			
$\gamma_{2,inf}$: Female, inflexible	-0.0024	(0.0015)	0.0000
$\gamma_{2,fle}$: Female, flexible	0.0225	(0.0020)	0.0001

Notes: This table reports the estimates and average marginal effects for parameters on the supply side of the model related to changes in costs, benefits, and probabilities of marriage and fertility. Standard errors for the estimates are included in parentheses. The average marginal effects for fertility and marriage are calculated for each labour type as the numerical derivative of the probability of choosing the specified occupation, with respect to the given probability of getting married or having children. These numerical derivatives are averaged across all relevant labour types and across all years for the relevant occupation to give the average marginal effects. In the case of earnings, the average marginal effects are calculated for each labour type and occupation as the numerical derivative of the probability of choosing the specified occupation with respect to earnings, and then these numerical derivatives are averaged across all labour types, occupations and years. For childcare costs and benefits, the average marginal effects are calculated as the numerical derivatives of the probability of choosing the specified occupation, with respect to the given childcare costs and benefits for the relevant labour type, and averaged for each sex and occupation.

Table 5: Marriage and Fertility Status of Men and Women in 1993 and 2017

	1993		2017	
	Men	Women	Men	Women
Marriage				
25-34	0.4901	0.5728	0.3544	0.4429
	(0.1882)	(0.1601)	(0.2015)	(0.2031)
35-44	0.8403	0.8624	0.7578	0.7629
	(0.0427)	(0.0444)	(0.0579)	(0.0358)
45-55	0.9348	0.9250	0.8306	0.8275
	(0.0155)	(0.0111)	(0.0377)	(0.0375)
Child under five				
25-34	0.2402	0.3045	0.2139	0.3160
	(0.1530)	(0.1436)	(0.1456)	(0.1526)
35-44	0.2779	0.2202	0.3792	0.3313
	(0.1184)	(0.1425)	(0.1196)	(0.1482)
45-55	0.0334	0.0052	0.0637	0.0206
	(0.0240)	(0.0075)	(0.0459)	(0.0284)

Notes: This table reports the means of the probabilities of being married and having a child under five, for men and women aggregated by age group, in 1993 and 2017. Standard deviations are reported in parentheses.

Table 6: Parameter Estimates: Time-varying Preferences for Occupations

	Estimates	SE
Age-, sex- specific preference for occupations, fixed over time		
$\psi_{0,f,25-34,inf}$: Female, 25-34, inflexible	0.1443	(1.0984)
$\psi_{0,f,25-34,fle}$: Female, 25-34, flexible	-0.2159	(1.5282)
$\psi_{0,f,35-44,inf}$: Female, 35-44, inflexible	-0.0959	(1.0933)
$\psi_{0,f,35-44,fle}$: Female, 35-44, flexible	-0.2416	(1.5276)
$\psi_{0,f,45-55,inf}$: Female, 45-55, inflexible	-0.0723	(1.0929)
$\psi_{0,f,45-55,fle}$: Female, 45-55, flexible	-0.2439	(1.5285)
$\psi_{0,m,25-34,inf}$: Male, 25-34, inflexible	0.5906	(1.6114)
$\psi_{0,m,25-34,fle}$: Male, 25-34, flexible	0.3494	(1.7653)
$\psi_{0,m,35-44,inf}$: Male, 35-44, inflexible	0.2041	(1.6294)
$\psi_{0,m,35-44,fle}$: Male, 35-44, flexible	0.0503	(1.7630)
$\psi_{0,m,45-55,inf}$: Male, 45-55, inflexible	0.0695	(1.6400)
$\psi_{0,m,45-55,fle}$: Male, 45-55, flexible	-0.0390	(1.7595)
Cohort-, sex- specific preference for occupations, fixed over ages		
$\psi_{0,f,90s,inf}$: Female, 1990s, inflexible	0.7226	(1.1511)
$\psi_{0,f,90s,fle}$: Female, 1990s, flexible	-0.1739	(1.5105)
$\psi_{0,f,00s,inf}$: Female, 2000s, inflexible	0.4442	(1.1507)
$\psi_{0,f,00s,fle}$: Female, 2000s, flexible	-0.3112	(1.5106)
$\psi_{0,f,10s,inf}$: Female, 2010s, inflexible	0.4085	(1.1513)
$\psi_{0,f,10s,fle}$: Female, 2010s, flexible	-0.0606	(1.5108)
$\psi_{0,m,90s,inf}$: Male, 1990s, inflexible	-0.0477	(1.5238)
$\psi_{0,m,90s,fle}$: Male, 1990s, flexible	-0.5485	(1.8193)
$\psi_{0,m,00s,inf}$: Male, 2000s, inflexible	-0.3887	(1.5272)
$\psi_{0,m,00s,fle}$: Male, 2000s, flexible	-1.0641	(1.8197)
$\psi_{0,m,10s,inf}$: Male, 2010s, inflexible	-0.1467	(1.5251)
$\psi_{0,m,10s,fle}$: Male, 2010s, flexible	-0.6244	(1.8176)

Notes: This table reports the estimates for parameters on the supply side of the model related to time-varying preferences for working in flexible and inflexible occupations. Standard errors for the estimates are reported in parentheses.

Table 7: Counterfactual Exercises

	(1) Data	(2) Model	(CF1) Demand	(CF2) Cohort	(CF3) Age	(CF4) Fertility	(CF5) Marriage	(CF6) Benefits	(CF7) Childcare
100 $\times\boldsymbol{\Delta}$ log (male/female) earnings ratio									
Life cycle: Δ_{55-25}	24.3	16.0	0.6	13.5	15.2	15.9	15.8	16.1	15.7
Time: $\Delta_{2017-1993}$	0.7	3.7	2.8	1.4	2.8	3.3	3.2	3.3	3.4
100 $\times\boldsymbol{\Delta}$ share working in flexible (versus inflexible) occupations									
Women									
Life cycle: Δ_{55-25}	-5.6	-2.6	-0.1	-0.5	-5.6	-2.6	-2.0	-1.9	-3.0
Time: $\Delta_{2017-1993}$	5.6	7.9	5.7	-0.3	6.8	6.7	6.0	6.1	6.6
Men									
Life cycle: Δ_{55-25}	-5.3	-4.3	-1.5	-4.3	-6.4	-4.2	-4.2	-4.2	-4.3
Time: $\Delta_{2017-1993}$	-4.6	0.2	-1.3	-1.6	-1.0	-1.1	-1.7	-1.0	-1.1
100 $\times\boldsymbol{\Delta}$ log (flexible/inflexible) earnings ratio									
Life cycle: Δ_{55-25}	-1.6	-9.0	-0.7	-14.0	-8.4	-9.3	-9.3	-9.3	-9.0
Time: $\Delta_{2017-1993}$	-13.7	-11.7	-18.7	-2.2	-16.1	-17.2	-15.3	-15.1	-16.0

Notes: This table reports a summary of changes over the life cycle and over time using the original data, the model predictions, and counterfactual estimates under alternative scenarios. The outcomes of interest are the log (male/female) earnings ratio, the share of men and women working in flexible occupations, and the log (flexible/inflexible) earnings ratio. Column (1) summarises changes in the averages of these outcomes between ages 25 and 55 and years 1993 and 2017 using the original data, and column (2) does the same using the model predictions. Columns (CF1) to (CF7) summarise the estimates of these averages under counterfactual scenarios. In Column (CF1), the demand shares for men and women conditional on gender and occupation $\alpha_{2,a,o,s}$ are assumed to remain constant at the level of the demand shares for labour of 25-34 years, over the life cycle. In Columns (CF2) and (CF3), supply-side preferences for working in flexible and inflexible occupations are assumed fixed over the life cycle at the levels in the 1990s over the sample period ($\psi_{0,s,c,j} = \psi_{0,s,90s,j}$), and at the levels at age 25-34 over the life cycle ($\psi_{0,s,a,j} = \psi_{0,s,25-34,j}$), respectively. In Columns (CF4) and (CF5), the gender- and age-specific rates of fertility and marriage, respectively, are assumed to remain at 1993 levels throughout the sample period (i.e. $Pr(\text{child} < 5 = 1 \mid s, a, t) = Pr(\text{child} < 5 = 1 \mid s, a, 1993)$ and $Pr(\text{marr} = 1 \mid s, a, t) = Pr(\text{marr} = 1 \mid s, a, 1993)$). In Columns (CF6) and (CF7), child-related benefits are assumed to remain at 1993 levels ($CBEN_{a,t} = CBEN_{1993,t}$) and childcare costs at zero ($CHC_{a,t} = 0$), respectively, throughout the sample period.

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A Data Appendix

The occupation classifications available in the QLFS were the UK Standard Occupation Classification - SOC90 from 1993 to 2000, SOC2000 from 2001 to 2016 and SOC2010 from 2011 to 2016. SOC2000 was the main classification onto which flexibility measures were mapped. Since the data spans two UK SOC classifications but the flexibility measure is available for US SOC 2000, a likelihood table (provided by the ONS) is used to assign UK SOC90 occupations to their most likely UK SOC2000 counterparts, in order to create a smooth UK occupation crosswalk matched over all years. The flexibility score in each UK SOC occupation in the dataset was calculated as the arithmetic mean of the reversed characteristics (as each individual characteristic is initially coded with higher values indicating lower flexibility), so that a higher flexibility score indicates an occupation with more flexibility. By definition, the flexibility score is fixed for an occupation over time, as the measure corresponds to O*NET characteristics for a fixed US occupational classification. The binary measure of a flexible occupation is created by defining an occupation as flexible if its flexibility score is above the median flexibility score across all occupations, which is a standard approach used in the literature to classify occupations in categories (Autor et al., 2003; Autor and Dorn, 2013).[13]

B Robustness Checks Using OLS and Multinomial Logit Analysis

As a robustness check, Table B.1 reports results from estimating the supply side of the model using OLS and multinomial logit regressions.[14] The OLS results show that the average hourly wage is positively associated with labour force participation, and negatively associated with home production in the MNL estimates. This is in

[13]The main descriptive statistics related to flexibility were tested with alternate binary cutoff thresholds, but this did not affect the main patterns observed. However, using cutoffs that were above the 75th percentile of the flexibility score led to very low shares of employment in flexible occupations, as occupations that employed a high share of graduates tended to have lower flexibility scores.

[14]The OLS regressions present linear probability model estimates of the probability of being active in the labour market for male and female graduates, controlling for age and cohort fixed effects, age- and sex specific average hourly wage, indicators for being married and having children under five, as well as the average amount of childcare costs and child-related benefits for women in their age group. The table also reports p-values from tests of equality between the coefficients in the male and female regressions. In the case of the multinomial logit regressions, average marginal effects are presented for each of the control variables on the probability of being in home production, or working in flexible and inflexible occupations. Reported p-values are from tests of the equality of the average marginal effects for working in flexible and inflexible occupations, as well as whether the average marginal effects for each occupational choice differs between men and women.

line with the above discussion, though the OLS estimates are significant only for men.

The OLS and multinomial logit estimates in Table B.1 also show that having a child under five at home makes women more likely to be in home production and less likely to work in flexible occupations, both of which are in line with the parameter estimates from the structural model, though the average marginal effects from multinomial logit are only significant at 10%. Results using OLS estimates finds that marriage makes men and women both significantly less likely to be in home production or work in flexible occupations and more likely to work in inflexible occupations. For women, this is different from the results in the model, but the reduced form estimation uses an indicator of marriage at the individual level, rather than the probability of being married in the age group, which may explain the differences in results.

The OLS and multinomial estimates suggest that higher average childcare costs are significantly positively associated with women being inactive in the labour market, whereas higher levels of child-related benefits are not significantly associated with their participation in the labour force or in any occupation, though there are insignificant effects on working in each of the market occupations. These estimated effects are in line with the parameter estimates reported by the model though they are not statistically significant.

Table B.1 also confirms using OLS and MNL estimation the model predictions that there were large increases in women in more recent cohorts working in flexible occupations accompanied by significant reductions in their probability of working in inflexible occupations, both of which are not seen for men. The difference in likelihood of working between the two types of occupations is statistically significant for women. On the other hand, both men and women in the oldest age group (45-55 years) are significantly less likely to be working in inflexible occupations, which does not vary by gender.

Table B.1: OLS and Multinomial Logit Regression Estimates of the Supply Side of the Model

	OLS			Multinomial Logit										
				Men				Women				*p-value m = f*		
	(1) Men	(2) Women	*p-value m = f*	(3) home	(4) inflexible	(5) flexible	*p-value inf = fle*	(6) home	(7) inflexible	(8) flexible	*p-value inf = fle*	*home*	*inflexible*	*flexible*
Age specific indicators: reference group 25-34 years														
age 35-44 years	-0.0047	-0.0237***	*0.0001****	0.0114	-0.0029	-0.0085	*0.6666*	0.0261***	-0.0291***	0.0030	*0.0073****	*0.0885*	*0.0207**	*0.1747*
	(0.0024)	(0.0030)		(0.0089)	(0.0095)	(0.0058)		(0.0037)	(0.0068)	(0.0057)				
age 45-55 years	-0.0283***	-0.0496***	*0.0081****	0.0422***	-0.0343***	-0.0079	*0.0262**	0.0508***	-0.0468***	-0.0040	*0.0254**	*0.3468*	*0.3349*	*0.7110*
	(0.0045)	(0.0058)		(0.0094)	(0.0071)	(0.0080)		(0.0074)	(0.0116)	(0.0088)				
Cohort specific indicators: reference cohort 1990s														
2000s cohort	-0.0092*	0.0130*	*0.0007****	0.0248***	-0.0147	-0.0102	*0.7775*	0.0052	-0.0517***	0.0466***	*0.0000****	*0.0257**	*0.0000****	*0.0000****
	(0.0037)	(0.0041)		(0.0071)	(0.0102)	(0.0070)		(0.0057)	(0.0067)	(0.0058)				
2010s cohort	-0.0077	0.0121***	*0.0008****	0.0005	-0.0027	0.0022	*0.6658*	-0.0079*	-0.0717***	0.0796***	*0.0000****	*0.1051*	*0.0000****	*0.0000****
	(0.0040)	(0.0031)		(0.0051)	(0.0064)	(0.0060)		(0.0033)	(0.0027)	(0.0052)				
Average wage	0.0021***	0.0021	*0.9919*	-0.0040***	0.0072***	-0.0031***	*0.0000****	-0.0050***	0.0070***	-0.0020	*0.0034****	*0.6449*	*0.3367*	*0.4860*
	(0.0006)	(0.0014)		(0.0015)	(0.0016)	(0.0011)		(0.0019)	(0.0020)	(0.0015)				
Married (indicator for individual)	0.0513***	0.0094	*0.0000****	-0.0706***	0.0831***	-0.0125	*0.0000****	-0.0310***	0.0507***	-0.0197***	*0.0000****	*0.0000****	*0.4120*	*0.0000****
	(0.0034)	(0.0062)		(0.0041)	(0.0075)	(0.0076)		(0.0081)	(0.0097)	(0.0033)				
Child under five (indicator for individual)	0.0004	-0.0836	*0.0365**	-0.0018	0.0107	-0.0089	*0.1853*	0.0823*	-0.0169	-0.0654*	*0.5968*	*0.0094****	*0.9866*	*0.0861*
	(0.0010)	(0.0381)		(0.0024)	(0.0080)	(0.0070)		(0.0338)	(0.0606)	(0.0333)				
Childcare costs (average for women with children under 5)		-0.0130*						0.0107***	-0.0116	0.0010	*0.4145*			
		(0.0054)						(0.0037)	(0.0094)	(0.0061)				
Child benefits (average for women with children under 5)		-0.0013						0.0009	-0.0020	0.0011	*0.1750*			
		(0.0009)						(0.0009)	(0.0015)	(0.0009)				
Constant	0.8939***	0.8796***												
	(0.0103)	(0.0210)												
Observations	653,287	723,508		653,287	653,287	653,287		723,508	723,508	723,508				
	0.0138	0.0302			0.0157				0.0175					

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table shows results from OLS regressions of male and female labour force participation and average marginal effects from a multinomial logistic analysis of selection into flexible or inflexible occupations (relative to the base category of home production). Included in parentheses are the OLS standard errors clustered at age group, sex, and year, and the standard errors for the marginal effects are calculated using the delta method using Stata's margins command. The regressions include controls for age- and cohort- specific dummy variables that influence participation in the labour market or in the occupations (relative to the omitted categories). Average wage is the average wage for a given age group and sex in a year, whereas average wage, flexible and average wage, inflexible are the average wages in flexible and inflexible occupations respectively for a given age group and sex in a year. Married and Child under five are included as indicator variables at the individual level. Childcare costs and child benefits are included as averages for women with children under five, for a given age group and year. Reported p-values are from tests of equality between the respective coefficients.