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The motherhood penalty in the United Kingdom: An unconditional quantile regression analysis

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Abstract. *Utilizing data from the UK Household Longitudinal Study, we employ panel methodologies and unconditional quantile regression (UQR) analysis to explore the prevalence and impact of the motherhood penalty within the context of the United Kingdom. Our panel findings underscore the persistence of a motherhood penalty for the average UK mother. However, our UQR findings reveal notable variations in the motherhood penalty across the wage distribution. Specifically, our UQR analysis reveals that the motherhood penalty is most pronounced in the bottom half of the wage distribution, remaining statistically significant across all quantiles up to the median. Thereafter, the magnitude of the motherhood penalty diminishes, eventually becoming a motherhood premium among the highest earners.*

Keywords: *motherhood penalty, UK Household Longitudinal Study, wage gap, United Kingdom, working mother, gender equality.*

1. Introduction

Across advanced industrialized societies, there is an abundance of empirical evidence that motherhood is associated with a reduction in women's hourly wages and that working mothers earn less than working women without children. This wage gap is a component of the motherhood penalty, a concept denoting the differential levels of remuneration and biases in perceived competence experienced by mothers at the workplace. Until recently, inquiries into the motherhood wage penalty were dominated by mean-based models that focused on the consequences of having children on the wages of the *average* mother. These studies generally indicate that the wage penalties of motherhood have been ebbing over the last three decades, albeit with considerable cross-country variations (Pal and Waldfogel 2016). Recently, however, the application of quantile methods has injected greater nuance into this story by revealing how the effects of motherhood fluctuate across the earnings distribution (Budig and Hodges 2010 and 2014; Cooke 2014; Killewald and Bearak 2014; England et al. 2016; Glauber 2018; Rios-Avila and Maroto 2022; Kwak 2022). Far from being a mere academic curiosity, these variations could blunt policymakers' attempts to mitigate the motherhood penalty because "an intervention that helps to raise the lower tail of an income distribution is often more appreciated than an intervention that shifts the median, even if the average treatment effects of both interventions are identical" (Frölich and Melly 2013, 346).

Most investigations of the motherhood penalty in the United Kingdom utilize mean-based models. In line with findings for other countries, this research suggests that the average UK motherhood penalty has fallen since the 1990s (see Waldfogel 1995 and 1998; Waldfogel, Higuchi and Abe 1999; Joshi, Paci and Waldfogel 1999) but is stubbornly persistent (Vagni and Breen 2021; Jones, Cook and Connolly 2023). Whether the UK motherhood penalty varies across the wage distribution has been less thoroughly investigated. The few studies that have employed quantile techniques in the UK context have important limitations. Cooke (2014), for example, uses unconditional quantile regression (UQR) to uncover nuances in the UK case, including a small wage *premium* among the lowest-paid mothers. However, that study draws on data from a single wave of the Luxembourg Income Study Database, which lacks the detailed individual-level data provided by the UK Household Longitudinal Study (UKHLS) dataset used here. The study is, moreover, a decade old and, with temporal fluctuations being a known feature of the motherhood penalty (see, for example, Glauber 2018; Kwak 2022), updated research is needed to understand the evolving nature of the relationship between motherhood and wages in the intervening period. Changes to the tax and benefit system underscore the need for a contemporary examination of the UK context. A recent appraisal by Cooke, Hägglund and Icardi (2022) partially addresses this criticism but, by confining their attention to private sector wages, they exclude the almost 5 million women employed in the public sector (almost one third of the UK female employees).

In this article, our aim is to explore further the existence and incidence of the motherhood penalty in the United Kingdom by applying panel methods and UQR analysis to data from waves 1–10 (2009–20) of the UKHLS. In doing so, our article makes important empirical and theoretical contributions to the ongoing debate about the motherhood penalty by adding greater nuance to our understanding of the relationship between the motherhood penalty and wage distribution. Empirically, our results corroborate the established narrative that, although the penalty has abated, motherhood in the United Kingdom is related to diminished female earnings, with incremental costs for additional children. Imitating research on other countries, UQR indicates that the effects of motherhood are spread unevenly and may even boost the remuneration of those at the upper end of the wage distribution (Glauber 2018; Kwak 2022). Specifically, compared with fixed effects analysis, UQR reveals a larger motherhood penalty for quantiles up to the median. Thereafter, the motherhood penalty dwindles, disappearing at the 75th quantile, before becoming a motherhood premium for the highest earners. Similarly, UQR models also show smaller penalties for mothers with greater educational attainment, occupational seniority and experience.

As well as identifying where the motherhood penalty is felt most keenly and by whom, our article contributes to theoretical explanations for the phenomenon. UQR is now the preferred method for gauging fluctuations in the motherhood penalty across the wage distribution (England et al. 2016). Yet, the application of this method has been confined to a handful of countries, most notably the United States. Idiosyncrasies in national institutions and social norms have a significant influence over the motherhood penalty. Accordingly, building robust theoretical explanations for variations in the motherhood penalty across the wage distribution demands insights from different country contexts. Given that women continue to bear a disproportionate burden of childcare responsibilities, the nature and extent of their participation in the workforce is shaped by the welfare regime and associated family policies (Stier, Lewin-Epstein and Braun 2001). Like the United States, the United Kingdom has a liberal welfare regime, providing only a residual safety net, which supposedly encourages self-sufficiency through participation in economic activity. These superficial similarities nevertheless mask important differences – not least that in the United States access to healthcare, paid maternity leave and sickness benefits is more dependent on employers. This, alongside the peculiarities of the UK welfare system, contributes to different employment patterns for mothers compared with those found in the United States (Musick, Bea and Gonalons-Pons 2020). For instance, the absence of available and affordable childcare in the United Kingdom has led to the concentration of women in part-time work in sectors characterized by lower wages.

The remainder of this article is organized as follows. Section 2 provides a review of the literature on the motherhood penalty, identifying some of the principal explanations for the phenomenon and its variance across the wage distribution. Section 3 sets out our methodology and the rationale for UQR. Section 4 presents our data and descriptive statistics, and section 5 discusses our results with an emphasis on the insights provided by UQR. Section 6 summarizes our findings and briefly considers some of the implications for public policy.

2. Literature review

2.1. Human capital, cultural norms and labour market institutions

Existing research consistently demonstrates that mothers receive lower hourly wages than their non-mother counterparts. Moreover, by controlling for individual characteristics, these studies have determined that this cannot solely be attributed to the varying selection into motherhood of women already predisposed to low wages (Gangl and Ziefle 2009; Budig and Hodges 2010; England et al. 2016). Here, we review some of the general explanations for the motherhood penalty, before considering the literature grounded in quantile methods, which explores the variation of that penalty across the earnings distribution.

The most prominent explanations for the motherhood penalty lean heavily on the theory of human capital (Becker 1985). They posit that the motherhood wage gap stems from discrepancies in measurable productivity arising from the differing human capital traits of mothers and non-mothers. The cumulative loss of education, training and experience following childbirth, occasioned by interruptions to employment and diminished hours of work, decreases mothers' productivity and, therefore, rewards (Anderson, Binder and Krause 2003; Gangl and Ziefle 2009; Glauber 2012; England et al. 2016). This is corroborated by research revealing that adoptive mothers suffer smaller wage penalties than biological mothers, possibly because the latter have longer career interruptions arising from carrying and nursing infants (Rosenbaum 2021). The disproportionate share of childcare responsibilities borne by women exacerbates divergences in human capital between mothers and non-mothers. Having children may inhibit the career trajectories of mothers by limiting their mobility or prompting them to settle for "family-friendly" posts which, while occupationally inferior and lower paid, enable them to balance family obligations with employment (Gangl and Ziefle 2009; Abendroth, Huffman and Treas 2014). Claims of smaller motherhood wage penalties among those who postpone childbirth pending career progression (Herr 2016) are inconclusive, with some studies finding that delaying fertility has little permanent effect on women's earnings (Rosenbaum 2020) or even amplifies the motherhood wage gap (Viitanen 2014).

Another dimension of the human capital argument is Becker's (1985) work-effort hypothesis, which holds that mothers are less productive at work because childcare responsibilities sap their energy. The hypothesis is lent credence by evidence that the motherhood wage gap is greater for women in demanding professions (Azmat and Ferrer 2017) or who have larger numbers of children (Viitanen 2014). Its truth notwithstanding, the proposition that mothers make less motivated, competent or dedicated employees is widely asserted. These stereotypes seep into the culture of organizations, whose recruitment, remuneration and promotion practices systematically discriminate against mothers (Correll, Benard and Paik 2007; Glass and Fodor 2018).

Typically, research estimates that human capital differences account for a quarter to two thirds of the motherhood wage gap. Human capital explanations, therefore, provide a powerful, albeit incomplete, narrative of the motherhood wage gap. With the importance of human capital varying between countries (see, for example, Gangl and Ziefle 2009), industries (see, for example, Glass and Fodor 2018; Halrynjo and Mangset 2022) and firms (Casarico and Lattanzio 2023), scholars have begun to probe the cultural and institutional milieu in which the motherhood wage penalty emerges.

Cultural explanations of the motherhood penalty centre upon how prevailing norms and beliefs regarding gender roles affect involvement in the workforce. These standpoints hold that the meaning of motherhood, and the behaviours appropriate for that social role, are constituted by conventions and expectations in the community to which mothers belong. These conventions are biased by gender assumptions that assign primary responsibility for family and domestic duties to women. At a societal level, underlying cultural assumptions have caused well-intentioned work–family policies to misfire. For example, Halrynjo and Lyng (2009) demonstrate how Sweden's generous parental leave policies led to career withdrawal by reinforcing pre-existing assumptions about the status of women as replaceable workers. At a sectoral or occupational level, perceived incompatibilities between maternal responsibilities and the norms and expectations of exemplary employees have also been proven to hinder the prospects of working mothers (Glass and Fodor 2018).

Influenced by these cultural assumptions, labour market institutions also affect the motherhood penalty. An assortment of job protections, subsidized childcare, paid parental leave and family income support schemes are now staples of the policy landscape in advanced industrialized countries (Olivetti and Petrongolo 2017). By reducing their time out of the workforce, these arrangements defray the human capital costs of motherhood, thus narrowing the motherhood wage gap (Budig, Misra and Boeckmann 2016; Waldfogel 1998). Country policies exhibit extraordinary diversity, however, resulting in varied, and occasionally perverse, effects on the motherhood penalty (see Mari and Cutuli 2021). For example, the effects of interventions designed to supplement incomes are offset by further human capital losses as they slow the return of mothers to the workforce. Similarly, the impact of these policies falls unevenly (Hook and Paek 2020). Indeed, they are often tailored to temper the challenges for those encountering the biggest disadvantages. Against this backdrop, the capacity to pinpoint the heterogeneous outcomes of motherhood across the wage distribution and forecast the probable effectiveness of policies to address these disparities is a critical tool for policymakers.

2.2. Motherhood penalties across the wage distribution

To audit the impact of motherhood at different points on the earnings distribution, researchers have turned to quantile regression. Using conditional quantile regression (CQR), Budig and Hodges (2010) find that the lowest-paid workers incur the severest motherhood wage penalty. The mechanisms precipitating the wage penalty also differ between lower-and higher-paid mothers, with work effort accounting for the penalty among the former and human capital losses being more salient as a factor for the penalty among the latter. A crucial limitation of CQR is that it only estimates the relationship between motherhood and wages at different points of the *conditional* distribution, for women whose wages are higher or lower conditional on the model covariates (Killewald and Bearak 2014). To overcome this, subsequent endeavours have applied UQR. Although the magnitude varies, studies using UQR typically uncover a J-shaped curve in the motherhood penalty across the wage distribution. The overarching pattern is that there is a gap between mothers and non-mothers at the bottom of the wage distribution, which widens and then peaks in quantiles up to the median. The motherhood penalty declines in the upper half of the wage distribution and vanishes by the top decile (Budig and Hodges 2014; Killewald and Bearak 2014) or becomes a motherhood premium (Glauber 2018; Kwak 2022). In short, the overall decline in the motherhood wage penalty indicated by mean-based models is driven primarily by high-earning mothers.

In part, the tapering of the motherhood penalty and the advent of a motherhood premium are the outcome of positive selection by high-wage women into parenthood and a corresponding decline in the proportion of working women with children in the bottom half of the earnings distribution (Kwak 2022). Beyond this, scholars theorize that the motherhood premium is rooted in human capital explanations. England et al. (2016) previously conjectured that individuals with the highest wages and skills incurred greater motherhood penalties because even brief absences from the workforce entailed substantial costs. More recent studies, in contrast, posit that high wages bestow mothers the means to mitigate the productivity drains traditionally assumed to accompany parenthood. High-wage mothers have the option to delegate some of their domestic duties, including child-rearing, thereby reducing interference with work productivity (Budig and Hodges 2010; Cooke 2014; Kwak 2022; Rios-Avila and Maroto 2022). High wages are also linked to occupations that offer employees flexibility and autonomy, enabling mothers to provide childcare while maintaining productivity through versatile work arrangements (Glauber 2018; Fuller and Hirsh 2019).

In the US context, productivity-related explanations are also given for other noted drivers of heterogeneity. For instance, although the United States mirrors the pattern of smaller penalties (or even premiums) among higher wage quantiles, the motherhood wage gap generally grows in parallel with the number of offspring (Cooke 2014; Glauber 2018; Kwak 2022). This conforms with long-standing views that larger families seem to curb maternal career prospects (see Yu and Hara 2021), albeit with high wages seemingly offering some insurance against this. Similarly, since the 1990s, married mothers in the United States have experienced smaller wage penalties than single mothers. The top decile of married mothers has enjoyed a wage premium throughout this period, but this did not surface among single mothers until 2015, a benefit which had by then spread to married mothers above the 70th quantile (Kwak 2022). This may reflect the advantages of higher wages in alleviating the impact of motherhood on productivity. Additionally, if the mothers' earnings exceed their partners', couples may be optimizing household income through the mothers becoming the main breadwinner, while partners take on more family and domestic responsibilities.

Research outside the United States reveals similar patterns of heterogeneity in the motherhood wage penalty but hints at a more important role for institutional explanations. In Australia and the United Kingdom, Cooke (2014) finds the largest motherhood penalties occurring between the 25th and the median quantiles and decreasing penalties across the upper half of the distribution. These gaps are smaller than those in the United States and, interestingly, UQR reveals a motherhood premium among the lowest earners. Based on private sector data, Cooke, Hägglund and Icardi (2022) compare the cases of Finland, Germany and the United Kingdom. A motherhood penalty exists across the entire distribution for the United Kingdom but with larger penalties for higher earners. In the case of Finland, mothers at the lowest quantiles suffer the largest penalties, but these decline and disappear by the 60th quantile and become a motherhood premium thereafter. In Germany, only those mothers at the median or the 80th quantile experience any significant wage penalty. These variegated results are partly attributable to institutional arrangements, such as the generosity or otherwise of family policies, which influence the extent and type of labour force participation among mothers (Gangl and Ziefle 2009; Budig, Misra and Boeckmann 2016).

3. Methodology

3.1. Multivariate OLS regression versus quantile regression

Panel methods and models based on multivariate ordinary least squares (OLS) regression are widely used in labour economics for empirical analysis. They are appropriate when the data are available in the right form and are "well behaved", with reference to normality assumptions for errors. Such empirical methods typically focus on the mean or other measures of central tendency in the distribution of the variable under consideration. If several restrictive assumptions relating to Gaussian distributions hold, OLS regression models can be correctly estimated, and we can infer all the relevant details about the conditional distribution of the dependent variable. In contrast, quantile regression methods enable us to determine a family of regression lines, each of which corresponds individually to a different quantile of the conditional distribution of the dependent variable.

Following Koenker and Bassett (1978), we assume that $\{y_i:i = 1, \ldots, T\}$ represents a random sample for a random variable Y, which has a distribution function F. Koenker and Bassett (1978) and Koenker and Hallock (2001) show that the sample qth quantile ($0 < q < 1$) can be expressed as a solution to the following optimization problem, involving minimization with respect to β in an equivalent manner:

$$\sum_{i:y_i \geq \beta}^{N} q\left|y_i - \beta\right| + \sum_{i:y_i < \beta}^{N} (1-q)\left|y_i - \beta\right| \quad (1)$$

In a classical linear regression model for regressing Y on a vector of covariates X, β*s* are computed by minimizing the sum of squared residuals. In a similar manner, β_q related to the qth conditional quantile function can be estimated by minimizing a sum of asymmetrically weighted absolute residuals (Koenker and Hallock 2001). This is represented as follows:

$$\min_{\beta_q \in \mathbf{R}} \sum \rho_q\left(y - x_i'\beta_q\right) \quad (2)$$

where $\rho_q(.)$ is the titled absolute value function, which is defined as $\rho_q(\varepsilon) = \varepsilon \cdot (q - I(\varepsilon < 0))$ for any $q \in (0, 1)$. The estimated coefficients, β_q*s*, can then be interpreted as partial or marginal effects, depending on whether the corresponding explanatory variable is continuous or categorical. Based on the objective function shown above, we can generalize to cover the linear regression case with $\{x_i:i = 1, \ldots, T\}$ representing a row of K-vectors and $\{y_i:i = 1, \ldots, T\}$ denoting a random sample arising from the regression process $u_i = y_i - x_i'\beta$ with a distribution F. In this setting, the qth quantile regression estimator $(\widehat{\beta_q})$ minimizes over β_q ($0 < q < 1$) as follows:

$$Q_N\left(\beta_q\right) = \sum_{i:y_i \geq x_i'\beta}^{N} q\left|y_i - x_i'\beta\right| + \sum_{i:y_i < x_i'\beta}^{N} (1-q)\left|y_i - x_i'\beta\right| \quad (3)$$

3.2. Unconditional quantile regression

UQR enables researchers to assess the impact of changes in the distribution of covariates or explanatory variables on quantiles of the unconditional (marginal) distribution of an outcome variable. This method involves the computation of a recentred influence function (RIF), which is then regressed on the explanatory variables. This approach avoids alternatives that are computationally burdensome and require non-parametric specifications and situations where missing data render the exercise intractable or infeasible.

Following Firpo, Fortin and Lemieux (2009), we can consider a UQR model as fitting a model to a set of covariates, say *X*, on a RIF that is particular to the quantile of interest. The RIF is a sum of both the value and the influence functions and is commonly employed in the robust statistics literature (Hampel et al. 1986). The influence function is the first derivative of a given estimator and it measures the magnitude of change in the distribution resulting from adding an extra observation (see Hampel 1974). An influence function enables us to evaluate the impact (or "influence") of adding or removing an observation on the value of a statistic, $\nu(F)$, without the need to recalculate it. The influence function can be defined as:

$$\mathrm{IF}\left(y;\nu\left(F\right)\right)=\lim_{\theta\to 0}\frac{\left[\nu\left(\left(1-\theta\right)\cdot F+\theta\cdot\delta_y\right)-\nu\left(F\right)\right]}{\theta},0\le\theta\le 1 \tag{4}$$

where F denotes the cumulative distribution function of Y and δ_y represents a distribution that puts only mass at the value y (Borah and Basu 2013). A RIF is then computed by adding the statistic to its influence function:

$$\mathrm{RIF}\left(y;\nu\right)=\nu\left(F\right)+\mathrm{IF}(y;\nu) \tag{5}$$

Such a RIF possesses a very attractive property, which is that its expectation equals that of $\nu(F)$. Consequently, if our statistic of interest is the mean, then the influence function (IF) is straightforwardly represented as the residual computed at that value of Y, while the RIF is simply the value of Y:

$$\mathrm{IF}\left(y;\lambda\right)=\lim_{\theta\to 0}\frac{\left[\left(\left(1-\theta\right)\cdot\lambda+\theta\cdot y\right)-\lambda\right]}{\theta}=y-\lambda \tag{6}$$

$$\mathrm{RIF}\left(y;\theta_\tau\right)=\theta+\left(y-\theta\right)=y \tag{7}$$

This means that the estimated coefficients from the UQR using the RIF can be explained (and interpreted) in a similar manner to OLS-based regression coefficients and they are applicable to any applied context involving any statistic of interest. Our main interest lies in explaining how motherhood (f_i) and a set of appropriate covariates (X_i) affect the hourly wage (Y_i) of individual *i* within the UKHLS dataset. In our article, Y_i is captured by the variable hourly wage (*hpay*). If we assume that our statistics of interest lie in the τth quantile, for this quantile τ, $\tau\in(0, 1)$, the RIF at a given quantile q, denoted as (ϕ (Y, q_τ, F_Y)), is given by the following expression:

$$\phi\left(Y,q_\tau,F_Y\right)=q_\tau+\frac{\tau-\chi\left(Y_i\le q_\tau\right)}{f_Y\left(q_\tau\right)} \tag{8}$$

where Y_i represents the value of the dependent variable; q_τ denotes the value of the τth quantile of the observed outcome variable; $\chi(Y_i \le q_\tau)$ is an indicator function that takes the value of 1 when the observed value is lower than the corresponding quantile of interest q_τ; and since F_Y is the cumulative distribution of Y, the marginal distribution is denoted by f_Y, which takes the value $f_Y(q_\tau)$ at q_τ. This expression does not include any covariates that make UQR particularly suitable (and stronger) when compared with conventional CQR methods (Koenker and Bassett 1978). Therefore, we obtain the following result by adding the statistic to its influence function:

$$\mathrm{RIF}\left(Y;q_\tau\right)=\phi\left(Y,q_\tau,F_Y\right)=q_\tau+\mathrm{IF}\left(Y;q_\tau\right) \tag{9}$$

The UQR method can be implemented using one of three estimation techniques (see also Firpo, Fortin and Lemieux 2009): OLS (RIF-OLS), logistic (RIF-logit), or non-parametric (called RIF-non-parametric). The computation of RIF-OLS is like OLS in general and in situations where our statistic of interest is the mean, the RIF-OLS estimates for the mean are exactly equal to OLS-based regression. The quantile regression model can be estimated using the ϕ (Y_i, q_τ, F_Y) evaluated for an individual *i*, and given the associated set of explanatory variables X_i. If fixed effects (γ_j) also need to be included, then the following second-stage regression is obtained (Borgen 2016):

$$\phi\left(Y_i, q_\tau, F_Y\right) = \alpha + \beta_\tau X_i + \gamma_j + u_j \quad (10)$$

In this context, our main research interest lies within the vector of coefficients β and the corresponding intercepts α. We assume that error terms u_j are independent, identically distributed with mean zero and constant variance within a region *j*. We can carry out model estimation using cluster-robust standard errors, which are particularly suitable when assuming unobserved heterogeneity among regions. By making use of a two-step process, as outlined here, it is easier to perform further diagnostic tests on the resulting coefficients. This approach allows us to obtain multiple models on the same dataset with different explanatory variables. A test for parameter equality across two quantiles of interest, say τ_1 and τ_2, is a test of the assumption that β_τ coefficients are identical in a regression of $\phi(Y_i, q_{\tau,1}, F_Y)$ and $\phi(Y_i, q_{\tau,2}, F_Y)$ on the respective *X* covariates. Since our distribution is the same, the first stage results do not change, and such a test can be carried out by using seemingly unrelated regressions with appropriate centring to account for fixed effects.

The type of quantile regression used by Koenker and Bassett (1978), CQR, helps us to evaluate the differential impacts of explanatory variables over the distribution of the outcome variable. This enables researchers to assess the impact of an explanatory variable on a specific quantile of the outcome or explained variable, conditional on specific values of other explanatory variables. This approach does have limitations, however, that UQR helps to surmount. First, CQR methods involve the evaluation of the impact of an explanatory variable on a quantile of the response variable, which is conditional on *particular values* of the other explanatory variables. Accordingly, CQR results are not easily generalizable or readily applicable within a policy context. UQR methods address this limitation by marginalizing the effects of other explanatory variables over the entire distribution, thereby making the results and the analysis more generalizable. Second, UQR methods provide us with an assessment of marginal effects over the distribution of other covariates within a chosen model and are more tractable and easier to interpret in policy terms. Third, UQR enables us to estimate standard partial effects, known as unconditional quantile partial effects. Lastly, CQR methods provide us with within-group effects, while UQR methods yield the total effect (the sum of between-group and within-group effects). This makes UQR methods more useful for analysing the unconditional partial quantile effects, which are particularly relevant for policy analysis.

Our empirical analysis commences with panel methods before moving on to UQR. Consistent with previous research, the logarithm of hourly wage is employed as the dependent variable in all model specifications. The key independent variable is *Children*, which represents motherhood and corresponds to the number of children under 16 in the household. Table 1 lists further regressors and a set of interaction terms. Lastly, we also include time dummies in all models to account for time effects, such as government policies that are not captured by the other regressors. The algebraic form of the model we employ is:

$$\ln\left(hpay\right) = \alpha_{i,t} + \gamma_{i,t} Children_{i,t} + \sum_{i=1}^{i=k} \beta_{i,t} Z_{i,t} + \epsilon_{i,t} \quad (11)$$

where γ is our main coefficient of interest, $Z_{i,t}$ is a full vector of controls for each individual (i)-wave(t) and $\epsilon_{i,t}$ is the error term.

4. Data and descriptive statistics

We carry out our empirical analysis employing data from 2009 to 2020, using ten waves of the UKHLS. UKHLS data incorporate annual waves of survey information about the socio-demographic characteristics of UK households and their members. Our sample includes women aged between 16 and 55, belonging to a household and who were surveyed in each wave. This approach excludes individuals who entered or left the household during this time. By doing so, we can construct a strongly balanced panel dataset with 22,311 individual-wave observations. Panel A in table 1 describes the original variables obtained directly from the UKHLS. We recode most categorical variables to minimize the number of categories, as some categories contain only a few observations. Panel B shows the variables after recoding. Our models are built using variables from panels A and B for each individual and each year where monthly wage data are accessible.

Table 1. Dataset

Panel A: Original variables in UKHLS	
Hourly wage (hpay)	Nominal wage per hour, obtained as the ratio between gross monthly salary and monthly working hours.
Age (dvage)	Age of the respondent at last birthday.
Children (nchild_dv)	Number of children under 16 in the household. Includes natural children, adopted children and stepchildren.
Hours worked (jbhrs)	Number of hours normally worked per week.
Current job (jbstat)	Current labour force status.
Region (gor_dv)	Government Office Region based on household's postcode.
Marital status (mastat_dv)	Marital status.
Maternity (matleave)	Binary variable equal to one if the respondent is currently on maternity leave.
Highest qualification (hiqual)	Current highest educational qualification.
Economic activity (jbnssec8_dv)	Eight categories based on the National Statistics Socio-economic Classification.
Panel B: Recoded variables	
Log of hourly wage (ln_hpay)	Natural logarithm of hourly wage.
Kids	Dummy variable equal to 0 if no children under 16 are ever recorded in the household. *Kids* is used as an interaction variable in all model estimations.
CurrentJob	Obtained by dividing "jbstat" into five categories: self-employed, paid employment, not employed, other, not in the workforce.
MaritalStatus	Obtained by dividing "mastat_dv" into four categories: single, married/couple, divorced/widowed, other.
JobType	Obtained by dividing "jbnssec8_dv" into three categories: high professional, intermediate, low responsibility.
Education	Obtained by dividing "hiqual_dv" into three categories: degree, intermediate degree, other/no qualifications.

Source: UKHLS and our own compilation.

Our dependent variable is the logarithm of hourly wage (*ln_hpay*), obtained as the ratio between gross monthly salary and number of hours worked per month. The main independent variable is the *Children* in the household. Following conventions within the literature, age, age squared, the number of hours worked per week, current labour force status, region of residence, marital status, highest educational qualification and type of economic activity are included as control variables. These controls allow us to include variables related to family policies that might affect wage differentials.

Table 2 presents descriptive statistics for the sample under analysis and for two subsamples: mothers and non-mothers. Mean hourly wages are similar across all groups, indicating consistency in earning patterns. There is variability within each group, as reflected by the minimum and maximum values, where mothers' wages are more dispersed around the mean. Mothers have 1.65 children on average, with a standard deviation of 0.70, indicating variation in family size. Consistent with the view that children diminish the number of hours worked, the average mother in the United Kingdom works six and a half fewer hours than non-mothers.

Table 2. Descriptive statistics

		Mean	SD	Min.	Max.	Observations
Non-mothers	Hourly wage (log)	2.57	0.51	–2.35	7.98	12 242
	Age	43.40	10.25	16.00	55.00	12 242
	Number of children	0.00	0.00	0.00	0.00	12 242
	Hours worked	33.01	9.31	0.10	97.90	12 242
Mothers	Hourly wage (log)	2.57	0.56	–4.80	9.02	10 069
	Age	40.43	6.55	20.00	55.00	10 069
	Number of children	1.65	0.70	1.00	6.00	10 069
	Hours worked	26.47	10.04	0.10	80.00	10 069
Full sample	Hourly wage (log)	2.57	0.54	–4.80	9.02	22 311
	Age	42.06	8.90	16.00	55.00	22 311
	Number of children	0.75	0.95	0.00	6.00	22 311
	Hours worked	30.06	10.18	0.10	97.90	22 311

Note: SD = standard deviation.
Source: Our own calculations using UKHLS data.

To complement our initial overview and to account for differences in volatility, we implement a simple *t*-test that compares the logarithm of hourly wage for mothers with that for non-mothers. The results show a negative and highly significant difference of –1.67 per cent in (log) wage for the full sample. Overall, the average wage of non-mothers exceeds that of the average mother by almost £1 per hour ($e^{-0.0167} = 0.98$).

Table 3 provides descriptive statistics for mothers and non-mothers across quintiles of log hourly wages, highlighting key differences in wages, age, number of children and hours worked. Both groups exhibit increasing wages as they move up the income distribution. Non-mothers tend to be older across all quintiles, particularly in the highest quintile, which could suggest differences in career trajectories. Mothers, on average, work fewer hours per week than non-mothers across all quintiles, reflecting potential caregiving responsibilities. The average number of children for mothers remains consistent, ranging from 1.6 to 1.7 across all quintiles. The table confirms key differences between mothers and non-mothers, especially in hours worked and wages, becoming more pronounced in the upper end of the income distribution.

Table 3. Descriptive statistics

			Mean	SD	Min.	Max.	Observations
Quintile 1	Non-mothers	Hourly wage (log)	1.91	0.28	–2.35	2.12	2 328
		Age	41.78	11.96	16.00	55.00	2 328
		Number of children	0.00	0.00	0.00	0.00	2 328
		Hours worked	29.51	11.99	2.00	97.90	2 328
	Mothers	Hourly wage (log)	1.90	0.33	–4.80	2.12	2 166
		Age	39.37	7.22	20.00	55.00	2 166
		Number of children	1.69	0.75	1.00	6.00	2 166
		Hours worked	22.00	10.40	2.00	80.00	2 166
	Full sample	Hourly wage (log)	1.90	0.30	–4.80	2.12	4 494
		Age	40.62	10.03	16.00	55.00	4 494
		Number of children	0.82	0.99	0.00	6.00	4 494
		Hours worked	25.89	11.86	2.00	97.90	4 494
Quintile 2	Non-mothers	Hourly wage (log)	2.26	0.08	2.12	2.38	2 455
		Age	43.12	10.72	18.00	55.00	2 455
		Number of children	0.00	0.00	0.00	0.00	2 455
		Hours worked	32.02	9.11	3.00	85.00	2 455
	Mothers	Hourly wage (log)	2.26	0.08	2.12	2.38	1 976
		Age	40.26	6.80	21.00	55.00	1 976
		Number of children	1.65	0.74	1.00	6.00	1 976
		Hours worked	25.36	9.28	2.00	60.00	1 976
	Full sample	Hourly wage (log)	2.26	0.08	2.12	2.38	4 431
		Age	41.84	9.29	18.00	55.00	4 431
		Number of children	0.73	0.96	0.00	6.00	4 431
		Hours worked	29.05	9.76	2.00	85.00	4 431
Quintile 3	Non-mothers	Hourly wage (log)	2.53	0.08	2.38	2.68	2 600
		Age	42.75	10.37	18.00	55.00	2 600
		Number of children	0.00	0.00	0.00	0.00	2 600
		Hours worked	34.04	8.08	3.00	80.00	2 600
	Mothers	Hourly wage (log)	2.54	0.08	2.38	2.68	1 862
		Age	39.99	6.41	24.00	55.00	1 862
		Number of children	1.64	0.71	1.00	5.00	1 862
		Hours worked	27.43	9.15	2.00	55.00	1 862
	Full sample	Hourly wage (log)	2.53	0.08	2.38	2.68	4 462
		Age	41.60	9.03	18.00	55.00	4 462
		Number of children	0.68	0.93	0.00	5.00	4 462
		Hours worked	31.28	9.14	2.00	80.00	4 462

(*Cont.*)

Table 3. Descriptive statistics (*concl.*)

			Mean	SD	Min.	Max.	Observations
Quintile 4	Non-mothers	Hourly wage (log)	2.83	0.09	2.68	3.01	2 523
		Age	43.68	9.48	19.00	55.00	2 523
		Number of children	0.00	0.00	0.00	0.00	2 523
		Hours worked	34.99	7.39	4.00	70.00	2 523
	Mothers	Hourly wage (log)	2.84	0.09	2.68	3.01	1 939
		Age	40.57	6.23	24.00	55.00	1 939
		Number of children	1.59	0.65	1.00	5.00	1 939
		Hours worked	28.78	9.34	2.00	60.00	1 939
	Full sample	Hourly wage (log)	2.84	0.09	2.68	3.01	4 462
		Age	42.33	8.37	19.00	55.00	4 462
		Number of children	0.69	0.90	0.00	5.00	4 462
		Hours worked	32.29	8.85	2.00	70.00	4 462
Quintile 5	Non-mothers	Hourly wage (log)	3.32	0.34	3.01	7.98	2 336
		Age	45.73	7.91	19.00	55.00	2 336
		Number of children	0.00	0.00	0.00	0.00	2 336
		Hours worked	34.26	8.48	0.10	70.00	2 336
	Mothers	Hourly wage (log)	3.33	0.40	3.01	9.02	2 126
		Age	41.91	5.68	25.00	55.00	2 126
		Number of children	1.68	0.66	1.00	4.00	2 126
		Hours worked	29.09	10.02	0.10	60.00	2 126
	Full sample	Hourly wage (log)	3.32	0.37	3.01	9.02	4 462
		Age	43.91	7.20	19.00	55.00	4 462
		Number of children	0.80	0.96	0.00	4.00	4 462
		Hours worked	31.80	9.60	0.10	70.00	4 462

Note: SD = standard deviation.
Source: Our own calculations based on UKHLS data.

5. Empirical results

5.1. OLS, fixed and random effects

This section presents estimates of the UK motherhood penalty using standard panel data methods, including pooled OLS, random effects (RE) and fixed effects (FE) models (see table 4). To address the existence and magnitude of a motherhood penalty, we employ the model $\ln(hpay) = \alpha_{i,t} + \gamma_{i,t} Children_{i,t} + \sum_{i=1}^{i=k} \beta_{i,t} Z_{i,t} + \epsilon_{i,t}$ as our baseline specification, which considers the logarithm of hourly wage as the dependent variable and *Children* as the main variable of interest. All estimations are obtained using heteroskedasticity-robust standard errors, which are reported in parentheses. Each model confirms the persistence of a wage gap for the average UK mother, albeit of varying proportions. Under OLS, the coefficient *Children*, representing the effect of each additional child on women's hourly wages, is negative and highly significant, suggesting a motherhood penalty. Since the log of hourly wages is the dependent variable, the coefficient can be translated as a percentage effect.

Thus, the OLS model finds that mothers earn 2.7 per cent less than non-mothers for each child they have. Published in the 1990s and based on even older data, most studies using OLS to gauge the UK motherhood penalty are outdated. Compared with these studies, our results suggest that the motherhood penalty is decreasing. This is in line with Harkness and Waldfogel (2003), who show that one child results in a 7 per cent wage gap for mothers, growing to 30 per cent for three or more children. Their model, however, does not consider a full set of control variables pertaining to the magnitude of the motherhood penalty. Using OLS, other control variables such as marital status, education and economic activity significantly affect hourly wages (see table 4).

Table 4. Motherhood penalty using least squares models

ln(hourly wage)	(1) OLS	(2) Random effects	(3) Fixed effects
Number of children	−0.027*** (0.007)	−0.061*** (0.008)	−0.069*** (0.009)
Age	0.053*** (0.003)	0.057*** (0.005)	0.047*** (0.012)
Age^2	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)
Working time	−0.005*** (0.001)	−0.010*** (0.002)	−0.011*** (0.002)
Paid employment	0.202*** (0.071)	0.209*** (0.070)	0.209*** (0.072)
Married/partnered	−0.179*** (0.067)	0.041 (0.087)	0.100 (0.099)
Divorced/widowed	−0.238*** (0.086)	−0.103 (0.108)	−0.083 (0.118)
Other	0.509** (0.252)	0.428* (0.258)	0.389 (0.264)
Intermediate degree	0.061** (0.030)	0.035 (0.051)	−0.086 (0.074)
Degree	0.287*** (0.031)	0.255*** (0.055)	−0.038 (0.082)
Intermediate responsibility	−0.366*** (0.025)	−0.133*** (0.026)	−0.038 (0.025)
Low responsibility	−0.693*** (0.029)	−0.346*** (0.036)	−0.173*** (0.036)
Constant	1.507*** (0.110)	1.374*** (0.141)	2.099*** (0.424)
Observations	22 311	22 311	22 311
R^2	0.372		0.187
Time effects	Yes	Yes	Yes
Number of PIDP		3 246	3 246

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.
Notes: Robust standard errors in parenthesis. PIDP = personal identifier.
Source: Our own calculations based on UKHLS data.

Results obtained using OLS may be severely biased in the presence of endogeneity. By imposing restrictions on the exogeneity assumptions of the cross-correlation between disturbances and the matrix of coefficients, RE models allow us to control for individual heterogeneity. The coefficient *Children* in the RE model is negative, significant and, at 6.1 per cent, indicates a considerably larger wage gap than OLS. We report estimates obtained using FE and test the efficiency assumption of the RE estimator using the Hausman test. The test result rejects the null hypothesis that an RE model adequately accounts for individual effects. Using FE models, which allow us to control for unobserved factors that might affect wages (Budig and Hodges 2010), we find a 6.9 per cent motherhood penalty for each additional child. As the slightly larger standard errors show, findings obtained using FE estimators are more robust. Accordingly, we compare our UQR results with those obtained using FE.

5.2. Unconditional quantile regression

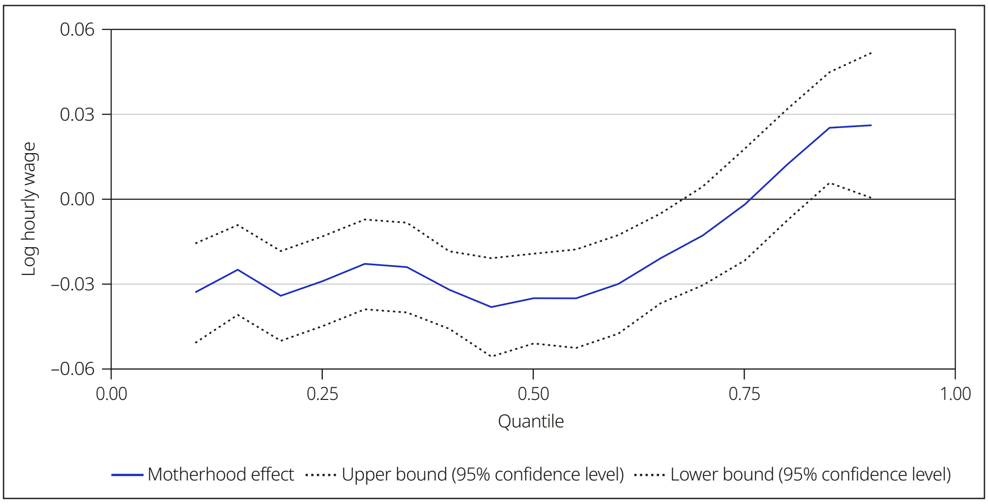
We estimate UQR using the same covariates described in our baseline model for each decile of the distribution of our dependent variable, the logarithm of hourly wage (see table 5). UQR reveals considerable variation in the motherhood penalty across the wage distribution (see also figure 1). At τ = 10th, the coefficient for *Children* is negative and statistically significant,

Table 5. Motherhood penalty using UQR models

ln(hourly wage)	(1) Fixed effects	(2) τ = 10th	(3) τ = 25th	(4) τ = 50th	(5) τ = 75th	(6) τ = 90th	Equality
Number of children	−0.069*** (0.009)	−0.033*** (0.010)	−0.029*** (0.008)	−0.035*** (0.009)	−0.002 (0.009)	0.026** (0.011)	20.2***
Age	0.047*** (0.012)	0.045*** (0.005)	0.056*** (0.004)	0.068*** (0.004)	0.057*** (0.004)	0.026*** (0.005)	5.67**
Age^2	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.000*** (0.000)	8.56***
Working time	−0.011*** (0.002)	0.003* (0.002)	−0.000 (0.001)	−0.005*** (0.001)	−0.007*** (0.001)	−0.007*** (0.002)	18.77***
Paid employment	0.209*** (0.072)	0.304*** (0.065)	0.243*** (0.053)	0.202*** (0.050)	0.048 (0.058)	−0.082 (0.076)	15.52***
Married/ partnered	0.100 (0.099)	−0.070 (0.093)	−0.117 (0.075)	−0.251*** (0.075)	−0.140* (0.075)	−0.253** (0.105)	1.63
Divorced/ widowed	−0.083 (0.118)	−0.074 (0.122)	−0.071 (0.094)	−0.155 (0.102)	−0.239** (0.111)	−0.391** (0.154)	3.22*
Other	0.389 (0.264)	−0.052 (0.369)	0.027 (0.299)	0.368 (0.358)	0.536* (0.319)	1.162** (0.488)	3.07*
Intermediate degree	−0.086 (0.074)	0.081 (0.071)	0.146*** (0.055)	0.095** (0.046)	0.119*** (0.031)	0.061* (0.037)	0.08
Degree	−0.038 (0.082)	0.206*** (0.069)	0.366*** (0.054)	0.435*** (0.046)	0.364*** (0.036)	0.190*** (0.038)	0.04
Intermediate responsibility	−0.038 (0.025)	0.006 (0.016)	−0.108*** (0.016)	−0.392*** (0.029)	−0.529*** (0.041)	−0.718*** (0.074)	81.83***
Low responsibility	−0.173*** (0.036)	−0.375*** (0.031)	−0.550*** (0.028)	−0.825*** (0.035)	−0.748*** (0.041)	−0.782*** (0.075)	23.15***
Constant	2.099*** (0.424)	0.527*** (0.154)	0.702*** (0.120)	1.171*** (0.128)	1.961*** (0.117)	3.208*** (0.157)	
Observations	22 311	22 311	22 311	22 311	22 311	22 311	
R^2	0.187	0.156	0.288	0.355	0.257	0.158	
Time effects		Yes	Yes	Yes	Yes	Yes	

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.
Notes: Standard errors in parentheses.
Source: Our own calculations based on UKHLS data.

Figure 1. Effects of motherhood across wage quantiles



Source: Our own calculations based on UKHLS data.

showing a 3.3 per cent penalty. The penalty persists and remains statistically significant across the lower half of the distribution, measuring 2.9 per cent at τ = 25th and 3.5 per cent at τ = 50th. Thereafter, the penalty declines monotonically and disappears completely at τ = 75th. Notably, the coefficient becomes positive and significant at τ = 90th, at 2.6 per cent, showing the presence of a motherhood premium. Echoing the findings for the United States (see Glauber 2018; Kwak 2022), the dwindling average motherhood penalty in the United Kingdom appears to be linked to improvements in the position of mothers in the upper quartile of the wage distribution.

In revealing a motherhood penalty across the lower half of the earnings distribution – which is widest in quantiles up to the median, but which then declines and becomes a premium among higher earners (see figure 1) – our findings broadly align with the pattern established by previous UQR-based studies (see Glauber 2018; Kwak 2022). Nevertheless, our results differ in subtle ways, related in particular to the specific context of the United Kingdom.

Our coefficients indicate a relatively consistent motherhood penalty across the bottom half of the earnings distribution. In contrast, previous studies have indicated that mothers in the second quartile face stiffer wage penalties than those in the lowest quartile. In the United States, Budig and Hodges (2014) find an 8 per cent penalty at τ = 25th and τ = 50th – almost double that at τ = 10th. Similarly, in the various cohorts examined by Kwak (2022), the relatively small (1–3 per cent) penalties at τ = 10th doubled or tripled by τ = 25th but remained relatively flat up to τ = 50th. This phenomenon is even more pronounced in the case of the United Kingdom, where mothers in the bottom decile accrue a 5 per cent wage premium, whereas those in the second quartile endure a 5 per cent penalty (Cooke 2014). Intriguingly, in the subsequent research by Cooke, Hägglund and Icardi (2022), this premium vanishes, showing an 8–10 per cent penalty among the bottom half of wage earners. Although further research is needed, the divergence between the cases of the United States and the United Kingdom, plus the evolution in the latter case, may lie in changing employment structures and their interplay with the welfare system.

Over the last 15 years, mothers in the United Kingdom and in the United States have exhibited similar employment levels but the nature of that work has differed drastically.[1] Whereas the proportion of mothers in part-time work in the United Kingdom is three times

[1] OECD, "OECD Family Database – LMF1.2 Maternal Employment", https://www.oecd.org/en/data/datasets/oecd-family-database.html#12345 (accessed 19 May 2025).

higher than in the United States, the proportion of mothers in the United States in full-time jobs is one and half times greater than those in the United Kingdom. To a point, this stems from the corporate welfare system in the United States, which ties various benefits to full-time occupations. This entices women, whatever their parental status, into full-time work. Equally, many partnered women in the United States depend on their partner's employment-related insurance. Additionally, many working women, particularly the less educated, are employed in posts lacking benefits, including health insurance. Concomitantly, the higher proportion of full-time working women in the United States reflects a more complex picture than a rational calculation around health insurance. It points to institutional and structural features of the US economy, including its less generous welfare system and its policies around wages and hours of work.[2]

Components of the UK public welfare system prompt mothers to settle for part-time posts in industries offering lower pay. Smaller penalties among low-wage mothers in the United Kingdom are possibly attributable to the selection of women into part-time work (Gangl and Ziefle 2009). In other words, among low-wage women in the United Kingdom, there is a gender penalty rather than a specific and additional motherhood penalty. Reforms to the UK welfare system may help account for the re-emergence of the penalty among lower earners. Commencing in 2013, the Government introduced Universal Credit, a single means-tested payment to replace six benefits and tax credits. This regressive reform has disproportionately impacted the incomes of the bottom decile (Brewer et al. 2020), something the Government hoped might stimulate greater workforce engagement. Confronted with modest public provision of early childhood education and care (ECEC) and the prohibitive costs of private alternatives, low-earning mothers may have left the labour force, having determined that additional childcare costs would exceed their earnings.

The finding that the UK motherhood penalty tapers above the median is in line with research on other contexts. That the penalty disappears (Killewald and Bearak 2014) or becomes a wage premium among the highest earning mothers is consistent with findings for the United States but is a novel observation for the United Kingdom. As figure 1 illustrates, the coefficient for *Children* turns positive, albeit statistically insignificant, at τ = 75th, continuing an upwards trajectory before cresting at a statistically significant premium of 2.6 per cent for mothers in the top decile. Previously, UK mothers at the 75th quantile were estimated to face a 2 per cent wage penalty, which subsided to nothing at the 90th quantile (Cooke 2014). In this regard, the UK motherhood penalty may be on a parallel trajectory to that of the United States, where the motherhood premium, which initially appeared among the top decile in the late 1990s, now benefits mothers in the top quartile of wage earners (Glauber 2018; Kwak 2022).

As in the United States, the wage premium among high-earning mothers in the United Kingdom probably reflects their remuneration. This gives them the financial wherewithal to outsource childcare responsibilities to third parties, enabling them to remain productive members of the full-time labour force. Exorbitant childcare costs are of less concern for higher earners, for whom the wage returns from employment outstrip additional childcare costs. High wages may also indicate occupations where individuals possess specialized skills that are hard to replace. This may compel firms wishing to retain skilled employees to offer generous post-maternity terms. Alongside attractive financial packages, mothers may receive workplace flexibility that enables them to balance their professional and personal lives (Goldin and Katz 2011). A fruitful avenue for future research is suggested by Buchmann and McDaniel's (2016) finding that US mothers in male-dominated professions (such as medicine and engineering) experience wage premiums, whereas their equivalents in female-dominated professions (such as teaching and healthcare) experience a penalty. This is especially pertinent to the case of the United Kingdom, where a highly segregated labour market distributes women unevenly across industries, with concomitant disparities in employment and wage opportunities (Leoncini, Macaluso and Polselli 2024).

[2] We thank our reviewers for helping us to clarify this point.

The premium may also reflect UK-specific developments since the publication of previous research. For example, over the last 15 years, the proportion of UK mothers working part-time has remained steady at 33–34 per cent, but the proportion working full-time has grown from 29 to 40 per cent.[3] As Cooke (2014) surmises, the attenuation of the motherhood penalty towards the upper end of the distribution probably reflects the fact that higher-earning British mothers are more likely to work full-time. The growing proportion of full-time working mothers helps account for the strengthening of this pattern. There is also evidence that families in higher-income deciles may be disproportionate beneficiaries of the quadrupling of ECEC expenditures by the UK Government since 2000 (Drayton and Farquharson 2023). Families in higher-income deciles tend to comprise two parents, which raises the question, explored below, of how relationship or family status affect the motherhood penalty.

5.3. Interactions

Theoretically, the presence of a partner with whom to share childcare responsibilities ought to attenuate the productivity problem widely thought to underlie the motherhood penalty. In practice, however, being in a couple may actually exacerbate the motherhood penalty by reinforcing the gendered division of labour. Indeed, the main factors contributing to the motherhood penalty operate in reverse for fathers, resulting in a fatherhood premium. While mothers assume the primary childcare obligations, reducing their availability for paid work and negatively affecting their perceived competence, the hours worked by fathers, who are perceived as more dedicated than non-fathers, are undiminished (Killewald and Gough 2013). For single women, the absence of a partner to provide financial support might increase the imperative to work, but childcare responsibilities could constrain their ability to do so, with contradictory outcomes for the motherhood penalty (see Harkness 2016).

To explore these dynamics, we interact our variables for motherhood and marital status, the results of which are summarized in table 6 and shown graphically in figure 2. Paralleling previous research, our analysis uncovers significant variations in the motherhood penalty according to the mother's relationship status. Starting with FE, compared with their non-mother counterparts, single mothers encounter a 7.3 per cent penalty, married mothers a 5.5 per cent penalty and divorced or widowed mothers a 5.1 per cent penalty (see table 6). However, the penalty is not significantly different from zero in statistical terms. In contrast, UQR analysis teases out some interesting nuances of these relationships. It suggests that motherhood penalties increase alongside wages, with mothers at τ = 90th earning up to 30 per cent less than their non-mother counterparts. Partnered mothers face smaller penalties than single mothers across all quantiles, the latter facing very severe penalties towards the upper end of the distribution (see figure 2 and table 6).

These results may seem puzzling given the evidence of a motherhood premium for high-earning mothers shown in figure 1. However, the two coefficients differ by construction and, therefore, should be interpreted differently. The premium at the 90th quantile in table 5 suggests that high-wage earners manage to overcome the negative impact of motherhood, potentially thanks to better support systems or workplace flexibility. This is not explicitly contradicted by table 6, as the interactions show penalties but do not preclude the existence of a premium for the number of children at high quantiles. Nevertheless, results arising from the interaction term are informative in the sense that they show the greater wage penalty suffered by single mothers compared with partnered mothers.

Studies using UQR have consistently found that the motherhood wage gap for single mothers is greater than for those with a partner. Nevertheless, the gaps shown by our results are significantly wider than those reported by Kwak (2022) in the United States. Moreover, in contrast to our findings, research in other contexts has tended to suggest a

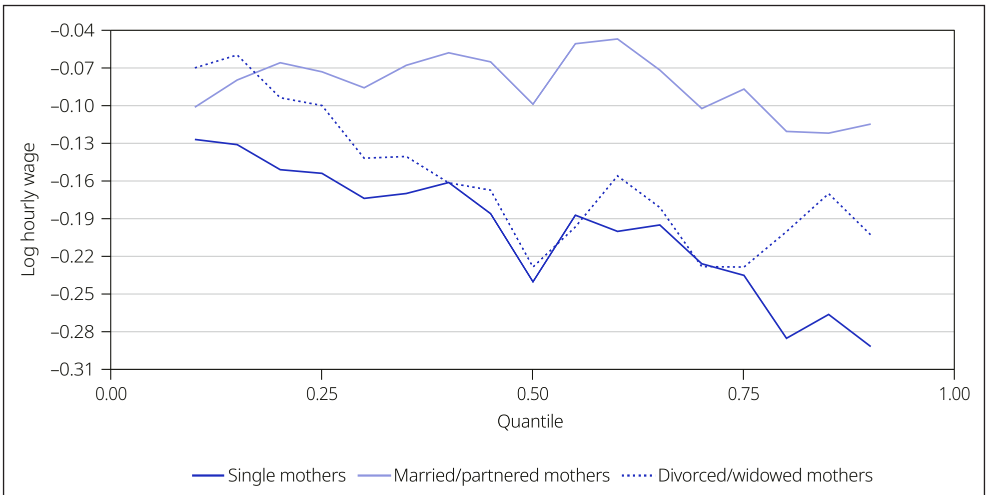
[3] See note 1.

Table 6. UQR interaction between marital status and motherhood

ln(hourly wage)	Fixed effects	τ = 10th	τ = 25th	τ = 50th	τ = 75th	τ = 90th
Single without children	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Single with children	−0.073 (0.058)	−0.127** (0.050)	−0.154*** (0.042)	−0.240** (0.044)	−0.235** (0.041)	−0.291** (0.052)
Married/partnered without children	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Married/partnered with children	−0.055 (0.052)	−0.101** (0.045)	−0.073* (0.038)	−0.099** (0.037)	−0.087** (0.035)	−0.115** (0.049)
Divorced/widowed without children	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Divorced/widowed with children	−0.051 (0.052)	−0.070 (0.050)	−0.100** (0.044)	−0.230** (0.043)	−0.229** (0.040)	−0.202** (0.056)
Other without children	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Other with children	−0.112 (0.117)	−0.052 (0.117)	−0.016 (0.082)	−0.152 (0.113)	−0.501** (0.157)	−0.485** (0.177)
Observations	22 311	22 311	22 311	22 311	22 311	22 311
R^2	0.187	0.156	0.288	0.355	0.257	0.158
Time effects	Yes					

* and ** indicate significance at the 10 and 5 per cent levels, respectively.
Notes: Standard errors in parentheses.
Source: Our own calculations based on UKHLS data.

Figure 2. Interaction of motherhood and marital status



Source: Our own calculations based on UKHLS data.

diminishing wage penalty among higher earners. This again may be the perverse outcome of some of the UK welfare policies. Epitomized by Universal Credit, the contemporary welfare system in the United Kingdom is predicated on drawing people, especially those on low incomes, into the labour force by ensuring that they are better off in work. Lower-paid mothers have strong incentives to enter paid employment, limiting their penalty compared with their non-mother counterparts. Paradoxically, gaps in the UK welfare system, such as an insufficient number of state-subsidized childcare places, may hit higher-earning mothers hardest. Without a partner to shoulder childcare responsibilities, these mothers may be compelled to sacrifice career opportunities by taking "child-friendly" or part-time jobs at the expense of higher wages, not least given the extremely high costs of private childcare in the United Kingdom.

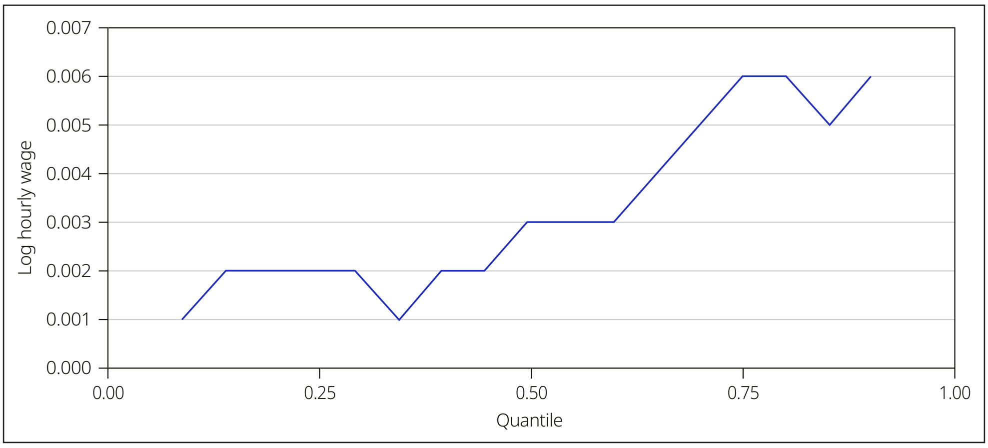
One aspect of this is the premise that mothers take positions that involve fewer hours, and this contributes to the pay differential with non-mothers. We test whether the number of hours worked increases the motherhood penalty across the wage distribution by modelling the interaction between *Working time* and *Children* (see table 7). The FE coefficient shows that, on average, mothers working more hours tend to earn relatively higher wages than non-mothers. The robustness of this result is tested by looking at how this wage premium varies across quantiles. Mothers earn significantly more than non-mothers, although the difference does not change materially with the wage distribution, suggesting that despite the premium being statistically significant, it only marginally contributes to a greater hourly wage for mothers. Figure 3 provides graphical confirmation of the stronger positive association between motherhood and hours of work, thus challenging the common misconception that the motherhood penalty arises because of a trade-off between the hours devoted to work and to parenthood.

Table 7. UQR interaction between working hours and motherhood

ln(hourly wage)	Fixed effects	τ = 10th	τ = 25th	τ = 50th	τ = 75th	τ = 90th
Working hours – non-mothers	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Working hours – mothers	−0.001 (0.001)	0.002** (0.001)	0.002* (0.001)	0.004** (0.001)	0.004** (0.001)	0.003** (0.001)
Observations	22 311	22 311	22 311	22 311	22 311	22 311
R^2	0.187	0.156	0.288	0.355	0.257	0.158
Time effects	Yes					

* and ** indicate significance at the 10 and 5 per cent levels, respectively.
Notes: Standard errors in parentheses.
Source: Our own calculations based on UKHLS data.

Figure 3. Interaction between motherhood and working hours



Source: Our own calculations based on UKHLS data.

6. Conclusion

This article has explored the motherhood penalty in the United Kingdom, and our FE models show the average mother enduring a 6.9 per cent wage penalty. Motherhood still deals a weighty financial blow, but the penalty is significantly smaller than that reported in the 1990s and 2000s. Nonetheless, UQR analysis indicates that this average conceals striking variations in the penalty across the wage distribution. Until the 75th quantile, all mothers suffer a motherhood penalty, but it is most severe for those in the bottom half of the wage distribution. Meanwhile, mothers in the upper quartile of the earnings distribution receive a motherhood premium, reaching up to 2.6 per cent among the top decile. As in the United States (see Glauber 2018; Kwak 2022), higher earners are driving the average decline in the UK motherhood penalty.

Our results also reveal subtle but important differences with previous UQR-based research. While research on the United States has regularly found a motherhood premium, this is the first study to find one among mothers in the upper quartiles of the UK earnings distribution. As in the case of the United States, we speculate that the explanation is that higher earners can dampen the productivity challenges of having children by paying third parties to undertake domestic and child-rearing duties. At the other end of the spectrum, the motherhood premium among the bottom wage decile reported in Cooke's (2014) earlier analysis of the United Kingdom has vanished. The finding that there is a wage penalty for those in quantiles up to the median is consistent with most other research. Compared with other studies, however, this penalty is more uniform, ranging from just 2.9 to 3.5 per cent. We suggest that the most likely explanations for these changes, and the variances from the US case, derive from the quirks of family policies and institutions in the United Kingdom and their repercussions for mothers' labour force participation. One of the paradoxes of the liberal welfare system, and its determination to encourage self-sufficiency by drawing mothers into the labour force, is that the benefits have flowed disproportionately to the better off. The welfare system incentivizes full-time work, which often correlates with higher earnings. Mothers at the lower end of the wage distribution, however, are more likely to work part-time. Given the gaps in ECEC, instead of transitioning from part-time to full-time work, welfare reforms may have prompted these mothers to exit the labour force altogether. Indeed, the growing divide in the penalties experienced by high- and low-wage mothers, as revealed by our analysis, ought to elicit questions about whether these policies are appropriately targeted. Rather than delivering social justice, the indiscriminate earmarking of support could subsidize those whose motherhood premium already bestows on them the necessary resources to combine work and motherhood.

Competing interests

The authors declare that they have no competing interests.

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