Assessing the impact of additional children on women's wages: An event study analysis using UKHLS data

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Abstract

This study examines the motherhood wage penalty (MWP) in the UK, where mothers tend to experience a decline in earnings following childbirth. It investigates how wage penalties evolve after first and second births and whether they vary by maternal age. High childcare costs and limited state support for working mothers make this a relevant policy concern. Using data from the UK Household Longitudinal Study the analysis derives a panel dataset to track women's wages over time. A range of model specifications have been tested to help address challenges common in this research area. An initial baseline two-way fixed effects model is used to establish whether a MWP is evident in the UK. The main analysis applies an event study framework to estimate wage changes in the years after childbirth. The findings show that first births are associated with larger and more persistent wage penalties than second births, with the worst penalties occurring in the year after birth. However, differences by maternal age are not statistically significant. These findings help highlight how the timing and sequencing of childbirth shape women's earnings and provide evidence that can inform policy and organisational approaches to support maternal employment.

AI Statement

I acknowledge the use of generative AI in *code development* in this paper. However, the work reported remains my own.

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1) Introduction

The motherhood wage penalty (MWP) refers to the pay disparity observed that women with children face when compared to childless women. In the UK, recent evidence shows that by the age of 42, mothers in full-time work earn 11% less than full-time women without children (Trades Union Congress, 2016). This wage gap persists beyond the transition into motherhood, reflecting the long-term career implications of motherhood.

The MWP presents a challenge for working mothers in the UK, with high childcare costs remaining a barrier to sustained employment. Childcare costs in the UK rank the third highest globally relative to wages according to OECD (2022). Despite reforms like the planned extension of 30 hours of funded childcare for working parents by September 2025 (UK Government, 2025), significant challenges remain. A recent report (O'Connor, 2023) showed that 24% of women return to full-time work after having children, and 79% of those eventually leave full-times roles, due to the difficulty of balancing paid work with caregiving. This reflects the need for better support to sustain maternal employment and earnings.

Further understanding of wage trajectories after childbirth is essential for developing policies that mitigate the long-term costs of motherhood. Factors such as the timing of childbirth and birth order likely influence the severity and persistence of wage losses. Early career interruptions may inflict lasting wage penalties, particularly for younger mothers who may have accumulated less work experience. Older mothers, by contrast, may absorb employment shocks more easily due to more likely having established careers.

The motivation for this study is to provide updated evidence on how wage penalties vary by birth order and maternal age, focusing specifically on how wage disparities evolve after childbirth. This research aims to inform policy that supports mothers' earnings.

The following hypotheses guide the analysis:

Hypothesis 1

- H_0: Wage penalty trajectories are the same after first and second births
- H_1: First births lead to larger and more persistent wage penalties than second births

Hypothesis 2

- H_0: Wage penalty trajectories are the same for younger and older mothers
- H_1: Younger mothers experience larger and more persistent penalties than older mothers

This paper reviews literature on the MWP, outlines the data and methodology used, presents results, and concludes with key findings and limitations.

2) Literature Review

2.1 Economic Theory

Previous literature identifies the loss of human capital accumulation as a factor driving the wage penalty associated with motherhood. Human capital refers to an individual's skills, competencies and experiences that contribute to their productivity, a more skilled workforce can work more efficiently and produce higher-quality outputs. As a result, greater human capital is associated with higher earnings potential. Becker (1962) argues that wage disparities arise from differences in human capital between mothers and non-mothers. Employment interruption due to child-rearing disrupts the accumulation of work experience and job specific skills, making it harder for mothers to progress to seniority in their careers. With fewer opportunities for promotion and skills development, their earning potential declines over time (Cukrowska-Torzewska and Matysiak, 2020). These effects may become even more pronounced with additional children as extended time out of the workforce exacerbates long-term wage penalties.

Becker's (1985) later research explores how childcare responsibilities influence mothers' job choices. He argues that because child-rearing is demanding, mothers who take on these responsibilities have less time to devote to paid employment. Unlike leisure or other unpaid activities, childcare requires ongoing efforts, which may limit the types of jobs mothers choose. To balance work and caregiving, they may prioritise jobs with greater flexibility, even if these roles offer lower wages. This trade-off can restrict investment in skills and career progression, reinforcing long-term earnings disparities. Becker's study solely focuses on married women, who have historically borne majority of the childcare duties, making them more likely to accept lower paying jobs that accommodate to caregiving roles. As family structures evolve and dual-income households become more common, mother's today may have less flexibility to trade earnings for work-life balance.

Another explanation for the MWP is employer discrimination. Budig and England (2001) argue that mothers often face disadvantages in hiring, promotion and pay because they are perceived as less committed or productive than childless women. These perceptions may not reflect actual differences in performance but can still result in reduced opportunities and lower wages. This reflects statistical discrimination, where employers rely on group-based assumptions over individual traits. In this context, motherhood serves as a proxy for lower expected productivity, especially when employers lack perfect information (Phelps, 1972). This can reduce employer investment in career progression and contribute to long-term wage penalties (Sigtona Halrynjo and Marte Mangset, 2024).

2.2 Empirical evidence

The MWP is a well-documented phenomenon, yet research on its long-term effects, particularly how wages change after the birth of additional children, remains limited. As more data becomes available tracking mothers' wages over time, researchers are increasingly interested in this area.

Many researchers apply a fixed effects (FE) model in MWP studies, aiming to account for both time invariant and measurable factors that influence fertility decisions and employment outcomes. Kahn, García-Manglano and Bianchi (2014) investigates the relationship between family size and hourly wages using the US National Longitudinal Survey of Young Women (NLSYM). Using a FE model, the study examines how the MWP evolves over time. Findings indicate that mothers with three or more children earn 17% less than childless women, with the penalty decreasing to 3.3% after controlling for years of work experience. To determine whether the wage penalty evolves over a women's life course, the study employs an age, parity interaction term. However, this was not statistically significant, suggesting that the penalty does not vary by maternal age at birth.

Education is often controlled for in studies of the MWP to better isolate its effects on earnings. Also using the US NLSYM, Long (2012), investigates the relationship between motherhood, educational attainment, and women's wages through a FE model. Findings show that having two or more children reduces women's wages by approximately 5.5%. However, the extent of this penalty diminishes with higher levels of education: mothers with a high school diploma experience a smaller reduction of 2.5%, while those with a college degree face the lowest penalty, at 0.5% relative to their wage gains. These findings highlight education's significant role in potentially offsetting wage losses associated with motherhood.

While FE models help control for time-invariant unobserved characteristics, they do not fully address the endogeneity of fertility decisions. Endogeneity arises when the causal relationship between childbearing and wage outcomes cannot clearly be identified, due to factors such as reverse causality, making it difficult to isolate the effect of additional children on wages.

Killian's (2017) theoretical framework highlights childbearing is a utility-maximising choice, where women weigh the benefits such as personal fulfilment and family life against the costs including career interruptions and time constraints. This means that women who have more children may differ from those who remain childless in terms of financial stability, career aspirations and personal priorities.

Killian (2017) emphasises that many models addressing the MWP assume homogenous preferences, meaning all women are considered to have similar attitudes towards their work-family trade-offs. However, individuals' preferences vary widely influencing both childbearing decisions and labour market outcomes. This assumption can oversimplify the relationship between motherhood and wages, contributing to an endogeneity problem. Wages and fertility mutually influence one another, making it difficult to determine whether additional children directly reduce earnings or whether women with weaker labour market prospects are likely to have larger families.

Although the FE model by Kahn, García-Manglano and Bianchi (2014) accounts for individual level heterogeneity, it fails to account for time-varying factors, such as career progression, macroeconomic conditions, and changes in household responsibility. This makes FE models unclear whether the observed wage penalty is causal or driven by external factors. To address this, researchers use Instrumental Variable (IV) methods, which use changes in family size that are independent of individuals labour market decisions.

One IV strategy uses the sex composition of woman's first two children to generate exogenous variation in fertility, based on evidence that European parents are more likely to have a third child if the first two are the same sex (Mills and Begall, 2010). If sex-mix influences fertility but not wages directly, the instrument satisfies the relevance and exclusion conditions. Hirvonen (2009), using a two-stage least squares model, finds that a third child reduces earnings by 32%, though not all years observed were statistically significant and standard errors are wider than in OLS estimates. This instrument may be considered weak now, as its ability to predict additional childbirth has likely declined due to modern family planning practices.

An alternative IV approach uses twin births as an exogenous shock, under the assumption that they are unplanned and independent of labour market behaviour. Chu et al. (2020) applies this method to examine how differences in gender pay gaps relate to variation in the motherhood employment penalty, measured by mothers like hood of remaining in the labour force following childbirth. The study finds that countries with smaller pay gaps tend to exhibit lower penalties. However, rearing two children simultaneously may influence a mother's willingness or ability to work differently that having children sequentially, potentially violating the exclusion restriction.

An emerging modelling strategy used for studying the MWP is the event study approach. This method captures how wages evolve around the time of childbirth, considering both the immediate and longer-term impact. It can strengthen causal interpretation by identifying whether wage trends existed prior to childbirth.

Event studies are commonly used to estimate dynamic treatment effects by measuring how a specific event, such as childbirth, influences an outcome across time using panel data (Miller, 2023). A widely adopted approach uses a two-way fixed effects (TWFE) event study, which accounts for both individual-specific and time specific unobserved factors. This is especially suited to staggered treatment timing (Li, n.d.), making it appropriate for studying childbirth, which occurs at different times across individuals.

Hsu (2021) applies and event study approach to examine the MWP in Japan, focusing on the effect of a second birth. Findings show a short-term wage penalty of 6.1%, which declines to 1.7% after ten years, suggesting a diminishing impact over time. However, this study focuses on Japan's labour market, which consist of long-hours work culture that can limit mothers' ability to remain in employment after childbirth (Brinton and Oh, 2019). As a result, the findings may not be generalised to the UK, where labour market structures and cultural expectations around work and care giving differ.

Event study analysis in the Russian labour market (Lebedinski, Perugini and Vladisavljević, 2022) illustrates how the MWP can vary by birth order. The results reveal that first time mothers experience wage penalties lasting up to five years, while penalties for second or higher-order births are shorter, typically two to three years. These findings align with earlier studies showing greater labour market withdrawal among first-time mothers (Hynes and Clarkberg, 2005; Klerman and Leibowitz, 1999). To account for differences in when childbirth occurs, the study also interacts event-time dummies with age, allowing the estimation of how penalties vary by stage of working life.

Kleven, Landais and Leite-Mariante (2023) expand on this by applying a pseudo-event study approach, which uses matching techniques to convert cross sectional data into a panel format, enabling the estimation of MWP's across 134 countries. Like the Japan and Russia studies, the analysis finds significant wage declines following childbirth. However, the persistence and scale of the penalty vary widely. In Denmark for instance, the MWP remains stable at around 14% with little recovery over time. This contrasts with the gradual wage rebound seen in Japan and shorter penalties observed for second births in Russia. Further reflecting the broader country differences in labour markets and family policy frameworks.

2.3 Contributions to literature

Most studies on the MWP focus on the impact of first births, offering limited insight into how wage penalties evolve with subsequent children. This gap in literature forms part of the motivation of this study. There is also a lack of recent UK-based research using longitudinal data to estimate the effects of higher order births. To address this, the study applies an event study framework to examine wage changes surrounding both first and second births, drawing on methodologies developed by Hsu (2021) and Kleven, Landais and Leite-Mariante (2023). In addition, the study incorporates an age interaction term, following the approach of Lebedinski, Perugini and Vladisavljević (2022), to assess how the timing of childbirth within a mother's working life shapes wage outcomes. By comparing penalties across birth order and age groups, this research contributes a more nuanced understanding of the MWP in the UK.

3) Data and variable construction

3.1 Data

This study uses a panel dataset derived from Understanding societies: The UK Household longitudinal survey, a survey that has tracked approximately 40,000 UK households annually since 2009 (Understanding Society, 2025). The survey collects a range of individual-level data on employment, earnings, fertility, and family structure across all waves of the survey. This analysis draws on 13 waves of data, from 2009 to 2022.

A list of the variables used, is provided in appendix table A1. The most recent wave (2023) is excluded due to low response rates. This mitigates concerns regarding longitudinal surveys, which experience non-random attrition as participants progressively drop out over time (Closer Learning Hub, 2025).

3.2 Sample

The sample consists of women aged 18 to 46 who were in paid employment during the observation period. This age range reflects typical childbearing age in the UK. According to the 2021 Census, the Office for National Statistics (2024) identified 46 as the average age which women completed childbearing responsibilities. Respondents with missing or ambiguous values in key variables were removed from the sample.

The final sample includes 9,938 women. To investigate the wage effects of childbirth, two sub-samples are constructed. The first includes women who transition from zero to one child, while the second captures transitions from one to two children. These are analysed separately to reflect differences in wage trajectories associated with each fertility transition. Of the full sample 3,194 women transition from zero to one child, and 4,383 transitioned from one to two children. Women who did not experience either transition remain in the dataset to preserve a balanced panel. Focus on the second birth transition is informed by the UK's average completed family size of 1.9 children per women (Office for National Statistics, 2024) reflecting a representative family size in the UK.

Women on maternity leave are retained in the sample following the approach of Lebedinski, Perugini and Vladisavljević (2022). In the UKHLS maternity leave is treated as continuous employment, with earnings reflecting statutory pay or employer-provided benefits. Excluding these respondents would bias the sample toward women with uninterrupted full-time work histories and underestimate the wage effects of childbirth. Including them ensures the analysis captures the full labour market consequences of fertility decisions, including periods of reduced earnings.

Figure 1

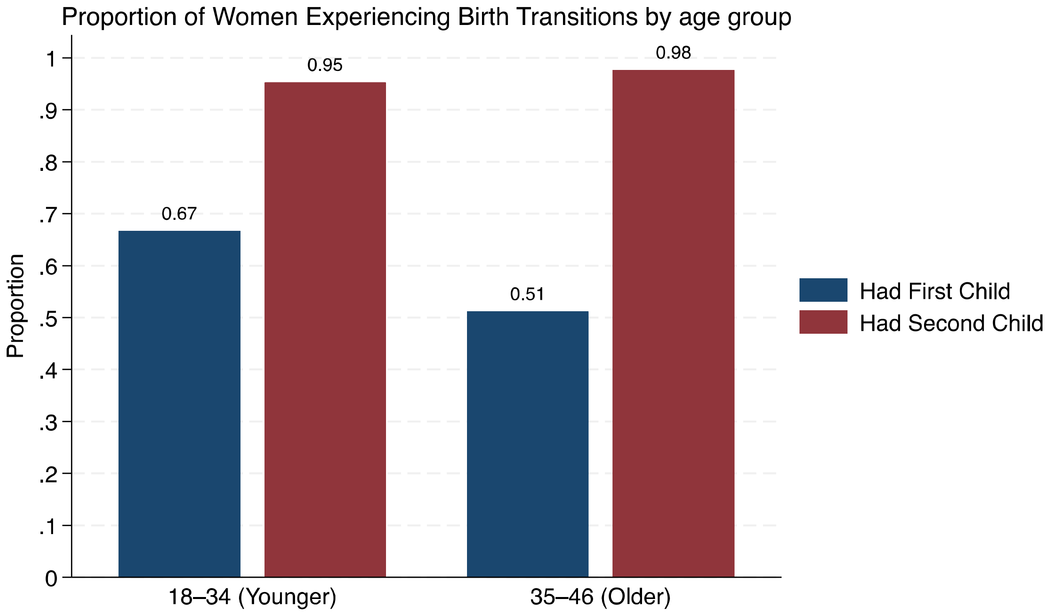


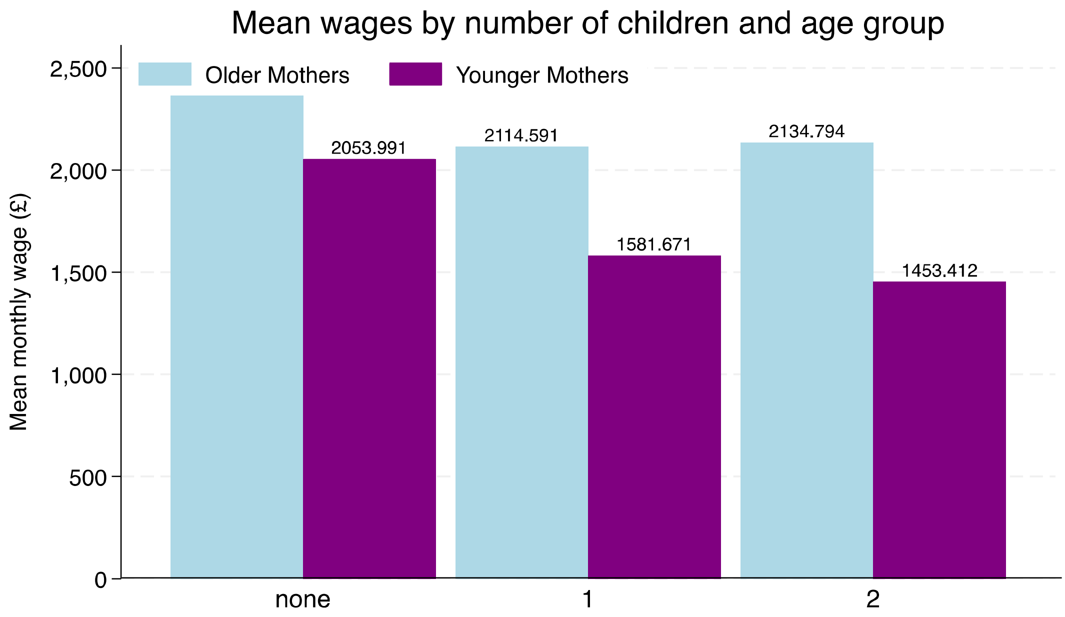
Figure 1 shows among younger mothers, 67% had a first child, and 95% of these went on to have a second. In contrast, 51% of older mothers had their first child during the observation period, and among them 98% has a second child. This may reflect age-related fertility factors and career timing considerations. Older mothers may face declining fertility and are more likely to time births strategically to align with established careers, leading to shorter intervals between childbirths and a desire to complete childbearing sooner. These patterns support the inclusion of age group interaction terms in the analysis. This study considers women aged 18-34 as younger mothers, while those aged 35 and older are classified as older mothers, in accordance with medical literature that identifies 35 as the threshold for advanced maternal age (Lavender, 2015).

3.3 Dependent variable

The dependent variable used in this analysis is total monthly gross income. The raw wage data was winsorised at the top 5% to address the positively skewed distribution of wages. Following this adjustment, the distribution of wages remained skewed, with a small number of women in the sample earning substantially higher incomes. This is common in wage data and may reflect underlying income inequality. To further address this, wages were log-transformed, which helped normalise the distribution reducing the impact of extreme values.

Figure 2 illustrates how average wages, measured before log-transformation, vary by number of children and maternal age group. For both age groups, wages decrease as parity increases, with sharper declines observed among younger mothers. Their average wages fall by 29%, from £2,054 with no children to £1,453 with two children. For older mothers, the decline is smaller at 13%, from £2,452 to £2,135. The difference in wage reductions further supports the inclusion of age group analysis.

Figure 2



3.4 Independent variables

The event study analysis uses event-time dummy variables to evaluate changes in wages relative to the timing of childbirth. Each woman is assigned an event year, defined as the year in which the number children increase. Dummy variables are created to represent each year before and after this event. Event-time dummies enable a flexible estimation of wage patterns around childbirth.

Separate event-time dummies are constructed for first and second births. A change from zero to one child is classified as a first birth, and a change from one to two children represents a second birth. Event time is calculated by subtracting the year of childbirth from the year in which the respondent was observed. The event window spans from t = -3 to t = 4, where t = 0 denotes year of childbirth.

Appendix table A2 presents summary statistics for variables used in the event study. Women in the second-birth sample have higher average wages, and 92% are partnered compared to 89% in the first-birth group, suggesting greater partnership likelihood among those progressing to a second child.

Women who experienced both a first and second birth during the panel are included in both samples, provided they meet the event-time window criteria for each analysis. Observations are not excluded when both transitions occur for the same individual. Each transition is analysed separate using a distinct set of event-time dummies, aligned relative to the specific birth year. This ensures that wages are measured independently around each birth transition, while preserving sample size and avoiding overlap within a single window.

3.5 Controls

Control variables have been included in the model to strengthen causal identification of the impact of additional children on wages. These variables were selected based on their potential influence on both the decision to have additional children and women's wages, as well as their frequent use in existing literature. Table 1 lists all controls.

Table 1

Variable	Type	Rationale/supporting literature
Partnership status	Binary	May affect fertility decisions and earnings potential (Budig and England, 2001)
Uses childcare	Binary	Captures access to support that enables continued work (Chhaochharia et al., 2017)
Highest qualification	Categorical	Acts as a proxy for skills and earning potential (Long, 2012)
Urban/rural residence	Binary	Reflects geographic variation in labour market opportunities (Killian, 2017)

This study considered using Standard Occupational Classification codes to control for job characteristics, as in Mott (2020), but did not include them due to poor response rates and limited coverage. Instead, highest qualification level is used to indicate skill and job seniority.

4) Methodology

4.1 Overview

This section outlines the empirical strategy used to estimate the wage effects of childbirth, with attention to differences by birth order and maternal age. Building on established methods, the analysis applies panel techniques that consider selection bias and unobserved individual differences. The design enables comparisons across mothers and time.

In line with empirical strategies commonly used in investigating the MWP (Gough and Noonan, 2013), this study employs a TWFE event study framework to examine the wage impacts of first and second childbirths. Fixed-effects are preferred given the panel structure of the data controlling for unobserved, time-invariant characteristics that may bias the estimates and addressing heterogeneity amongst individuals (Chwastek and Mynarska, 2024).

The methodology used in this study follows an iterative testing process on previous models. A baseline TWFE model is first estimated without controls to establish the initial relationship between additional children and wages. Robustness tests are subsequently conducted, guiding the inclusion of controls to improve model validity. These tests are repeated separately for both first and second birth models.

Building on this, an event study specification is introduced to track wage trajectories following childbirth. The final model specifications address heterogeneity by age group by interacting event-time dummies with a binary variable indicating older and younger mothers, allowing comparison of how wage penalties differ across ages (Angelov, Johansson and Lindahl, 2016).

4.2 TWFE model

A FE model is initially employed to estimate the baseline relationship between the cumulative number of children and wages. A TWFE model is deemed appropriate for an event study analyses as it effectively accounts for both individual heterogeneity and time-specific shocks. Miller (2023) note, that TWFE models are commonly used in event studies as they can effectively control for confounding omitted variables that vary at either individual or time level. This relationship is outlined in model 1 below.

Model 1:

$$\ln{(wage)_{it}} = \beta_1 nchild_{it} + \alpha_{it} + \lambda_t + \varepsilon_{it}$$

Where:

- β_1 - the cumulative effect of each additional child on wages
- α_{it} - individual fixed-effects
- λ_t - time fixed-effects
- ε_{it} - error term

A Hausman test is conducted to justify the use of a FE model over a random effects (RE) model of the same specification. The null hypothesis (H_0) of the Hausman test states that the RE model is consistent, implying no correlation between unobserved factors and the explanatory variables. Rejection of H_0 based on a highly significant p-value ($p<0.001$) indicated that a RE model would be inconsistent due to potential endogeneity, confirming that the FE model is preferred.

Individual fixed effects controls for unobserved time-invariant factors that may influence both wage trajectories and the decision to have additional children. As Budig, Misra and Boeckmann (2012) highlight this could include individual career ambition and cultural attitudes towards child-rearing priorities that are not easily measured and cannot be captured by the variables used in this study.

A joint F-test on the time fixed effects indicate that they should be included ($p<0.001$). Time fixed effects account for macroeconomic conditions, such as general wage inflation and economy-wide shocks, that vary over time but affect individuals in the sample uniformly. Including year dummies allows the model to account for shifts in wages that are unrelated to individual characteristics or fertility decisions. While some studies (Lebedinski, Perugini and Vladisavljević, 2022) account for the economic cycle by including a lagged GDP growth rate variable as a control, using time fixed effects captures a range of time-specific factors influencing wages. By accounting for inflation, changes in the labour market conditions, and policy reforms, time fixed effects provide a holistic adjustment for external influences that could bias the estimated wage effects.

The Wooldridge test identifies serial correlation within individuals over time, rejecting the H_0 at the 1% significance level. As robust standard errors correct only for heteroskedasticity, they underestimate variability in the presence of autocorrelation. Consequently, clustered standard errors are used in all models to address both heteroskedasticity and within-individual error dependence.

4.3 Inclusion of controls in baseline models

Building on the baseline specification, Model 2 adds a group of time-varying[1] control variables commonly used in the MWP literature. These include indicators for partnership status, highest qualification and urban or rural residence, all selected to reduce omitted variable bias and improve model fit. In a TWFE model, only variables that vary within individuals over time can be identified, as FE absorb all time-invariant characteristics. All control variables selected show within-person variation, confirmed by non-zero within standard deviations.

A variable capturing childcare was initially considered but excluded from the final specification. Descriptive statistics reveal that the majority of women in the sample did not use formal childcare during the study period, resulting in limited within-person variation. When included childcare caused the main coefficients of interest to become statistically insignificant. This is likely due to endogeneity arising from unobserved factors such as informal family support or flexible working arrangements, which can influence both childcare use and wages. Given these concerns, childcare was excluded from future model specifications.

Model 2:

$$\ln(wage)_{it} = \beta_1 nchild_{it} + \beta_2 X_{it} + \alpha_{it} + \lambda_t + \varepsilon_{it}$$

Where:

- X_{it} – control variables

To assess multicollinearity, a variance inflation factor (VIF) test is employed after the inclusion of controls. Multicollinearity occurs when independent variables in a regression are correlated, which can lead to inflated standard errors (Ph. D and Kavlakoglu, 2023). The average VIF across all control variables is 5.9, which is below the threshold of 10, suggesting that

[1] Urban rural residence and highest qualification are treated as time-varying due to observable transitions across survey waves, potentially due to relocation of attainment of additional education

multicollinearity is not a major concern. However, the VIF values for some categories of the highest qualification variable are relatively high.

The highest qualification variable is coded as a set of dummy variables representing different education levels. A correlation matrix shown in appendix table A3 indicates moderate intercorrelation between some categories. This likely reflects similarities in the characteristics of individuals across different qualification levels within the sample and may explain the elevated VIF values. However, no correlation coefficients exceed 0.52, suggesting that multicollinearity is present but unlikely to bias the results substantially.

4.4 Event study framework

Model 2 is extended using a staggered event study specification, which is appropriate where individuals experience an event at different times. In this case, childbirth is the event, and the model aligns each woman's wage data relative to the year she gave birth, estimating average wage changes before and after the event.

The explanatory variable in this model shifts from a cumulative indicator of the number of children to a series of event-time dummy variables that capture wage changes in each year surrounding childbirth. While earlier specifications estimate the average effect of having an additional child, the event study allows wages to be tracked before and after childbirth, with $t < 0$ representing pre-birth years and $t > 0$ post-birth years. Each woman's post-birth wages are evaluated relative to her own pre-birth wages, treating the individual as her own control.

Separate event-time dummies are constructed for the first and second birth transitions. The dummy variable for the year prior to birth ($t = -1$) is excluded from both models. This year is assumed to reflect a stable period in women's wages before any labour market disruptions due to childbirth and is therefore used as the reference category. Gangl and Ziefle (2009) provide empirical support for this choice, showing that wages tend to remain stable up to the year before childbirth. The omission of this variable also avoids perfect multicollinearity with the other event-time dummies and year fixed effects. All remaining event-time dummies are interpreted relative to this year. The event study specifications are shown below.

Model 3a: First-birth

$$\ln{(wage)_{it}} = \sum_{t \neq -1} \beta_t^{1st} \cdot EventTimeDummies_{it}^{1st} + \beta_2 X_{it} + \alpha_{it} + \lambda_t + \varepsilon_{it}$$

Model 3b: Second-birth

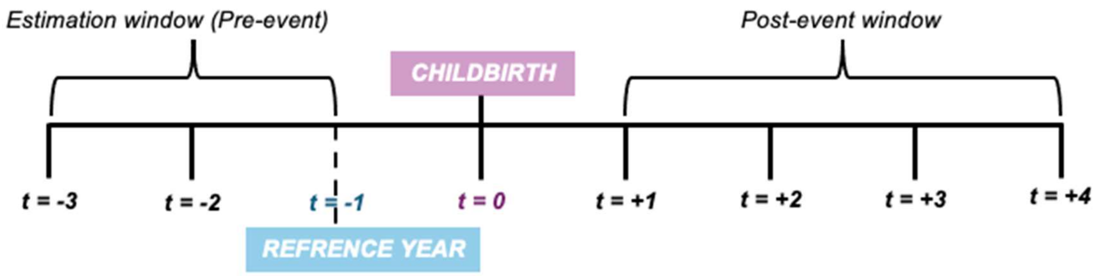
$$\ln{(wage)_{it}} = \sum_{t \neq -1} \beta_t^{2nd} \cdot EventTimeDummies_{it}^{2nd} + \beta_2 X_{it} + \alpha_{it} + \lambda_t + \varepsilon_{it}$$

Where:

- $\sum_{t\neq-1}\beta_t^{1st}\cdot EventTimeDummies_{it}^{1st}$ – Dummies for each year before and after the first-birth
- $\sum_{t\neq-1}\beta_t^{2nd}\cdot EventTimeDummies_{it}^{2nd}$ – Dummies for each before and after second-birth

This study uses an event window that spans three years before and four years after childbirth. Although previous research, including Lebedinski, Perugini and Vladisavljević (2022) and Kleven, Landais and Leite-Mariante (2023), typically adopts wider windows of five to ten years, this analysis uses a shorter window due to data limitations. An inspection of the data[2] indicated that extending the window would reduce the number of valid observations. This is because many women experience additional births within a few years of their first or second child, making it difficult to observe wages without the cofounding effects of subsequent births. Restricting the window to $-3 \leq t \leq +4$ preserves sample size and strengthens causal interpretation. Figure 3 illustrates the event window.

Figure 3



A key condition for the event study approach is the parallel trends assumption. This requires that, in the absence of childbirth, wages would have continued along a similar path over time. When this assumption holds, pre-event wage patterns provide a credible counterfactual for estimating post-event changes (Angrist and Pischke, 2009), this is confirmed by formal tests on the event study framework.

4.5 Heterogeneity by age group

[2] A histogram of event-time dummies under wider windows, showed sample attrition and suggested increased cofounding from later births

The impact of childbirth on wages may differ by age, reflecting variations in career stage and human capital. To explore this, the final models (4a and 4b) [3] include interaction terms between event-time dummies and binary indicators for age group at childbirth. Age is fixed in the year of childbirth to ensure that the assigned age group corresponds to the timing of the event. These interaction terms allow the model to estimate separate wage trajectories for younger and older mothers. Separate interaction terms are included for the first and second birth transitions. The resulting coefficients reflect how wage outcomes differ by age group in each year, relative to the reference period.

5) Results

This section presents the results from the models outlined in the methodology. All models use a log-linear functional form, so coefficients are interpreted as a percentage change in wages, calculated by exponentiating the coefficient, subtracting one, and multiplying by 100. Where appropriate, findings are compared with relevant theories and existing literature to provide context for the magnitude and persistence of wage effects.

5.1 TWFE vs RE

Table 2 presents baseline TWFE and RE estimates examining the relationship between the number of children and women's wages.

[3] The full equation of these models is not show due to length and complexity of notation but is clearly described in the text

Table 2[4]

Variable	*FE*	*RE*
n_child	*-0.111*** (0.012)*	*-0.075**** (0.011)*
Partner	*-0.022 (0.029)*	*0.034 (0.023)*
Urban/rural	*-0.025 (0.031)*	*-0.030 (0.020)*
Degree	*0.631**** (0.135)*	*0.363**** (0.096)*
Other Higher	*0.483**** (0.124)*	*0.053 (0.098)*
A-level	*0.292*** (0.118)*	*-0.118 (0.096)*
GCSE	*0.390**** (0.129)*	*-0.205*** (0.098)*
Other Qualification	*0.220**** (0.071)*	*-0.091 (0.103)*
Year FEs	*Included*	*Included*
N	*9,938*	*9,938*
R^2 (within)	*0.062*	*—*

The TWFE model estimates that each additional child is associated with an 11.1% reduction in wages, after controlling for time-invariant individual characteristics and time-varying covariates. This finding supports expectations that motherhood alters labour market participation in ways that may constrain wage growth. Even among mothers who remain employed, the magnitude of the penalty aligns closely with panel studies such as Gough and Noonan (2013) who report a 10% wage reduction per child in a US sample.

Educational attainment shows strong positive associations with earnings. Women with degrees earn 61.3% more than those with no qualifications (reference category), and those with A-levels earn 29.2% more. These findings are consistent with human capital theory, which links education to increased productivity and labour market value. Including education as a control ensures that the effects of childbearing are not conflated with differences in pre-existing earnings potential. Although the moderating role of education on the MWP is not directly estimated, previous studies (Long, 2012) suggest that higher qualified women may experience smaller wage losses, partly due to access to higher paying roles.

Partnership status and urban residence do not exhibit statistically significant effects in the TWFE model, despite both variables displaying non-zero within-person standard deviations. This suggests that changes in these characteristics may not consistently lead to wage changes.

[4] Throughout this paper, coefficients are presented with standard errors shown in brackets adjacent, significance is indicated by *p < 0.1, **p < 0.05, and ***p < 0.01

The non-significance of the urban-rural dummy likely reflects high levels of residential stability; for example, UK evidence shows that 71% of families remain in the same residence from pregnancy through to children's early childhood (Tunstall, Pickett, and Johnsen, 2010). This stability may limit the ability of TWFE models to detect wage differences associated with location. Similarly, changes in formal partnership status may not shift household labour divisions in ways that influence women's earnings. Bonnet and Jeandidier (2018) also report similar empirical challenges and highlight that numerous MWP studies using FE find no significant effect of marriage or partnership on wages, particularly when the analysis does not include interactions or is not stratified by subsamples.

The RE model produces a smaller estimated wage penalty of 7.5% and weaker associations between education and earnings, likely due to bias from time-invariant factors not accounted for in this specification. In contrast, the TWFE model uses individual variation to better isolate the impact of childbirth on wages and provides the foundation for the event study analysis that follows.

5.2 Event Study

Table 3 shows the estimated wage effects for the years surrounding first and second birth, using a TWFE event study model specifications.

Table 3

Variable	*First Birth*	*Second Birth*
3 years before	*-0.0722 (0.1017)*	*-0.030 (0.070)*
2 years before	*-0.0136 (0.0768)*	*-0.043 (0.105)*
Year of birth	*-0.0998** (0.0442)*	*-0.064 (0.051)*
1 year after	*-0.140*** (0.0393)*	*-0.074* (0.042)*
2 years after	*-0.1189*** (0.0387)*	*-0.075** (0.033)*
3 years after	*-0.0801** (0.0392)*	*-0.055** (0.025)*
4 years after	*-0.0142 (0.0405)*	*-0.037** (0.018)*
Partner	*0.0351 (0.0426)*	*-0.043 (0.041)*
Urban/rural	*0.0142 (0.0530)*	*-0.062 (0.049)*
Degree	*0.132 (0.115)*	*-0.084 (0.096)*
Other Higher	*0.299** (0.123)*	*-0.232*** (0.074)*
A-level	*0.346*** (0.113)*	*-0.406*** (0.067)*
Other Qualification	*0.0796* (0.0448)*	*0.139*** (0.024)*
Year FEs	*Included*	*Included*
N	*3,194*	*4,383*

For first births, the largest wage decline occurs in the year after childbirth, with a statistically significant reduction of 14%. Significant penalties persist in the second and third post-birth years (11.9% and 8%, respectively), before becoming insignificant by the fourth year.

The larger penalty associated with first births may reflect the greater disruption this transition brings to mothers' employment. The initial shift to parenthood often causes a major disruption to working life, as mothers may reduce their hours, take maternity leave, or move into more flexible roles. These changes can slow career progression and limit wage growth, leading to a more lasting impact on earnings than subsequent births.

For second births, a wage penalty is first observed in the year after birth, though it is smaller at 7.4%. This remains statistically significant up to the fourth year and narrows to 3.7%.

The smaller wage penalty observed after second births may reflect that many mothers may have already adapted their work and childcare arrangements after the first child. Once systems around employment adjustments and childcare are in place, additional births may cause less disruption to earnings. Hsu (2021) reports similar results with a 6.1% wage penalty after the second birth and a reduction in the penalty by 4.4 percentage points over ten years. Although the event window in this analysis is shorter, the direction and scale of the effect are consistent.

The within R-squared reflects the proportion of variation in wages explained by changes in the independent variables within individuals over time. The second birth models show a higher R-squared (0.102) than the first (0.060), potentially due to the larger sample size. However, the R-squared should be interpreted with caution, as it does not establish a causal relationship between wages and the explanatory variables. To support the validity of the event study findings, further robustness checks have been conducted.

Figures 4 and 5 plot the event-time dummy coefficients from the TWFE model for first and second births, with 95% confidence intervals shown as grey bars.

Figure 4

Figure 5

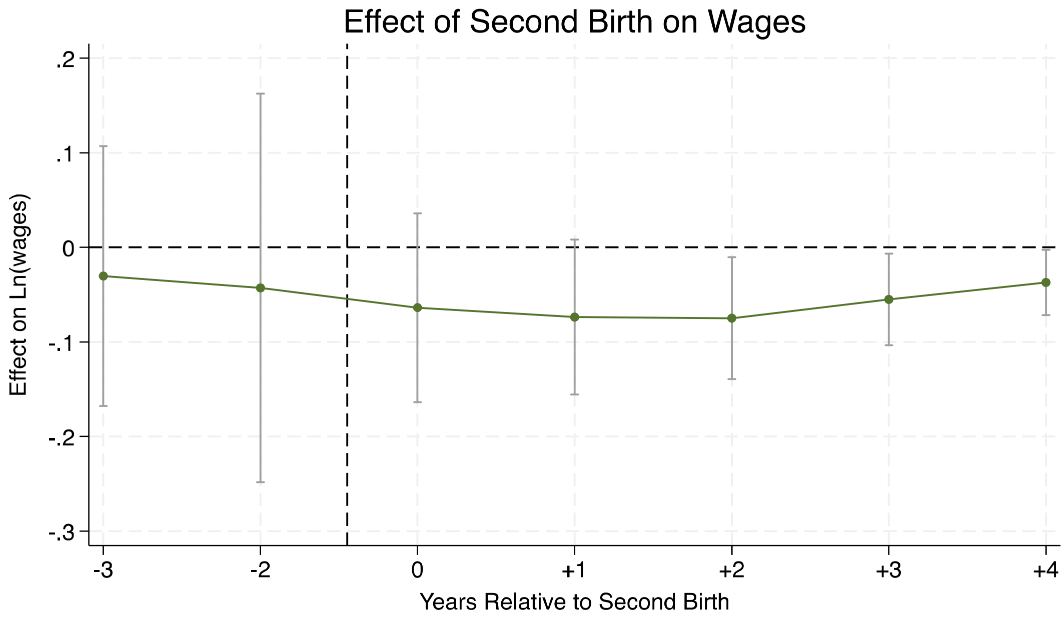


Figure 3 for first births show a sharper and more sustained decline in wages, with statistically significant reduction observed through to the third year after birth. In contrast Figure 4 shows the decline in wages following second births is less pronounced and levels off earlier. By the fourth year, the estimated wage reduction for second-time mothers narrows to 3.7%, compared to the steeper losses experienced by first-time mothers.

The relatively moderate penalty observed in the year of childbirth for first and second births, potentially reflects the structure of maternity leave in the UK. Mothers are entitled to up to 39 weeks of statutory paid leave (GOV.UK, 2013), most of which occurs during the year the child is born. As a result, earnings in the birth year are less likely to reflect immediate changes in working hours or employment arrangements. The sharper decline in wages in the year after birth coincides with the end of this leave period, when many women return to work, often on reduced hours. In contrast, Russian analysis by Lebedinski, Perugini and Vladisavljević (2022) finds the largest wage drop in the year of birth, likely due to shorter leave entitlements. Statutory maternity pay in Russia covers 20 weeks, prompting earlier return to work.

5.3 Robustness of Event Study

To assess whether the parallel trends assumption holds, joint F-tests are conducted on the pre-event time dummies for t = -3 and t = -2. These tests fail to reject the H_0 that the pre-birth coefficients are jointly equal to zero, with the F-statistics of 0.28 ($p = 0.757$) for the first birth model and 0.14 ($p = 0.872$) for the second birth model, supporting the validity of the assumption. Visual inspection of the event-study graphs shows a slight upward trend in wages before first birth, but this movement is not statistically significant, while wage trajectories before the second birth remain relatively flat. Evidence from formal tests and visual inspection strengthens confidence that post-birth wages changes reflect the impact of childbirth rather than pre-existing wage differences.

The confidence intervals around the estimated post-birth coefficients are relatively narrow in the first two years after childbirth, and the estimated effects for both first and second births lie reasonably far from zero suggesting a wage penalty during this period. However, confidence intervals widen considerably in later post-birth years for first births, indicating increasing uncertainty about longer term effects. This widening likely reflects a loss of precision as event study models estimate multiple event-time dummies, which reduces degrees of freedom (Miller, 2023). Small differences beyond two years post-birth should be interpreted with caution, as they may reflect sampling variability rather than true wage changes.

Another way to assess the robustness of event study models is through placebo tests. These tests check the validity of the results by assigning a treatment when no real event has occurred (Egami and Yamauchi, 2022). In this study, a fake childbirth is assigned two years before the birth. Figures 6 and 7 plot the estimated wage effects around these placebo events. In both cases, the wage trajectories remain relatively flat, with no visible patterns or statistically significant post-event dummies. The absence of wage responses reinforces confidence that the results reflect the impact of childbirth rather than spurious wage shocks.

Figure 6

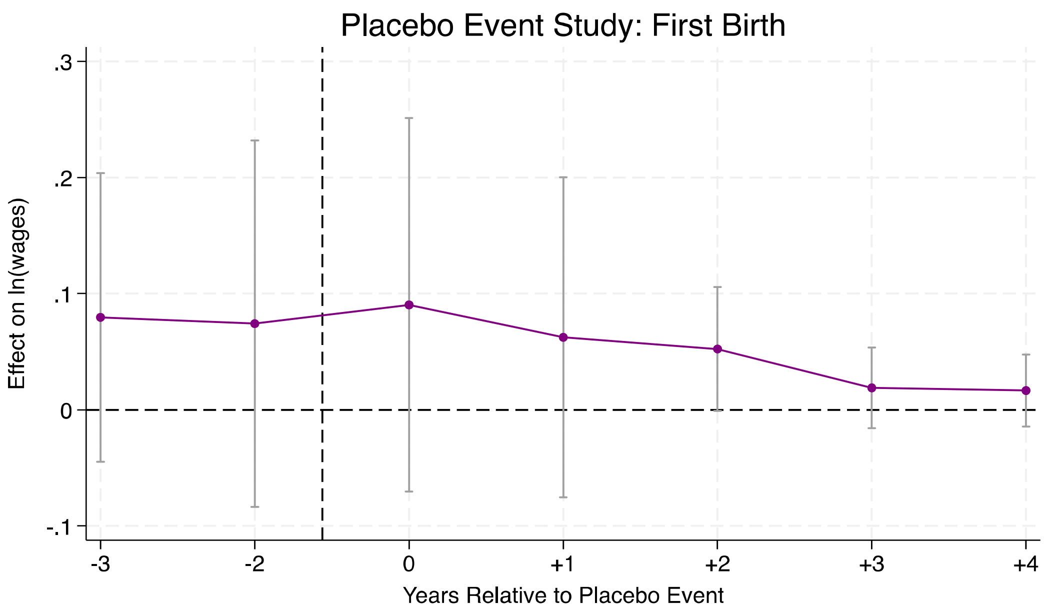
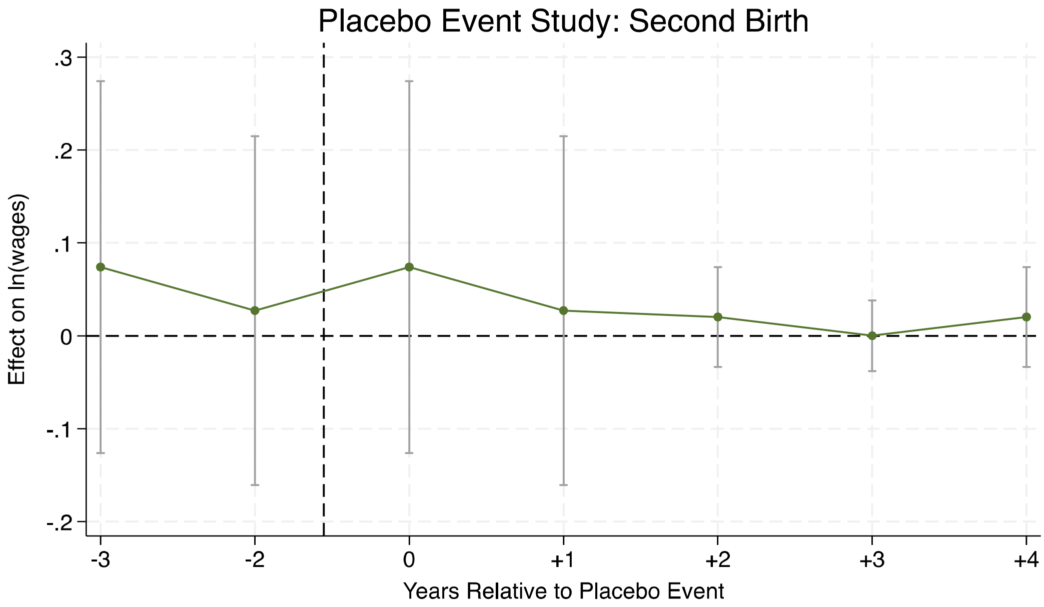


Figure 7


Placebo Event Study: Second Birth
.3
.2
.1
0
-.1
-.2
Effect on ln(wages)
-3
-2
0
+1
+2
+3
+4
Years Relative to Placebo Event

5.4 Event study: Heterogeneity by age-group

Using interaction terms between even-time dummies and age group indicators, Table 4 and Table 5 estimates separate wage trajectories by age group relative to pre-birth baselines for first and second births respectively.

Table 4: First-birth

Variable	***Older***	***Younger***
3 years before birth	*-0.284*** (0.085)*	*-0.054 (0.108)*
2 years before birth	*-0.133* (0.077)*	*0.009 (0.085)*
Year of birth	*-0.075 (0.073)*	*-0.108** (0.046)*
1 year after birth	*-0.130** (0.055)*	*-0.147*** (0.041)*
2 years after birth	*-0.122* (0.062)*	*-0.148*** (0.040)*
3 years after birth	*-0.079 (0.061)*	*-0.084** (0.042)*
4 years after birth	*-0.136* (0.081)*	*0.017 (0.043)*
Partner	*0.038 (0.042)*	*0.038 (0.042)*
Urban/rural	*0.016 (0.053)*	*0.016 (0.053)*
Degree	*0.177 (0.135)*	*0.177 (0.135)*
Other Higher	*0.338** (0.143)*	*0.338** (0.143)*
A-levels	*0.385*** (0.134)*	*0.385*** (0.134)*
GCSE	*0.380*** (0.143)*	*0.380*** (0.143)*
Other Qualification	*0.130* (0.071)*	*0.130* (0.071)*
	N: 3,194	
	Within R^2: 0.063	
	Year Fixed Effects Included	

Table 5: Second-birth

Variable	***Older***	***Younger***

3 years before birth	*-0.156** (0.069)*	*-0.052 (0.107)*
2 years before birth	*0.027 (0.112)*	*-0.163 (0.136)*
Year of birth	*0.001 (0.043)*	*-0.138*** (0.040)*
1 year after birth	*-0.056 (0.034)*	*-0.117*** (0.033)*
2 years after birth	*-0.061** (0.028)*	*-0.111*** (0.028)*
3 years after birth	*-0.079*** (0.023)*	*-0.022 (0.024)*
4 years after birth	*-0.070*** (0.018)*	*0.040 (0.025)*
Partner	*-0.045 (0.039)*	*-0.045 (0.039)*
Urban/rural	*-0.068 (0.046)*	*-0.068 (0.046)*
Degree	*-0.188** (0.087)*	*-0.188** (0.087)*
Other Higher	*-0.317*** (0.076)*	*-0.317*** (0.076)*
A-levels	*-0.422*** (0.066)*	*-0.422*** (0.066)*
GCSE	*-0.315*** (0.035)*	*-0.315*** (0.035)*
Other Qualification	*0.198*** (0.026)*	*0.198*** (0.026)*
N: 4,383		
Within R^2: 0.119 *Year Fixed Effects Included*		

The parallel trends assumption holds for younger mothers before both first births with F-statistics of 0.23 (p=0.796) and second births with F-statistics of 0.71 (p=0.490), but this is not met for older mothers at second births with F-statistics of 3.12 (p=0.045). This difference in pre-trend validity requires caution when interpreting age-group results.

Some post-birth wage penalties are significant across both age groups. For example, following first births, younger mothers experience a wage penalty of around 14.7% while older mothers see a decline of 12.25%. After second births, younger mothers again show larger wage losses, with a penalty of 11.1% two years post-birth compared to 6.1% for older mothers. However, F-tests comparing all post-birth coefficients between younger and older mothers consistently fail to reject the H_0 that wage penalties are equal across age groups at all post-birth years for both first and second births.

While wage penalties appear descriptively larger for younger mothers, the statistical evidence does not support a robust difference in wage trajectories by age. Given the absence of statistically significant differences in post-birth coefficients, and violations of the parallel trends assumption for older mothers, the models do not permit strong causal conclusions about age-related heterogeneity in the MWP.

5.5 Limitations

As discussed throughout this paper, several limitations must be recognised when interpreting these results. A key challenge is the endogeneity of motherhood. Childbirth is not a random event, but a decision shaped by individual circumstances and the choice to transition into motherhood that is not easily incorporated into empirical analysis (Killian, 2017). These influences concurrently affect wage patterns, complicating efforts to isolate childbirth's specific impact. Timing regarding when women choose to have children relative to career stability and the intervals between multiple births introduce further challenges to causal identification.

To address endogeneity more effectively, and correct selection bias that may distort event study estimates, an IV approach could be used. Studies have exploited external sources of variation such as twin births to better isolate the impact of additional children, as shown by Chu et al. (2020) and Hirvonen (2009). However, the UKHLS does not reliably identify twin births across waves, meaning these methods could not be applied to this analysis. Although the event study models control for individual characteristics to some extent, unexpected developments following childbirth, such as shifts into part-time work or reliance on informal childcare, may still influence wages. These factors may cause correlation in the error terms over time for the same person which is partially mitigated but not completely removed by clustering individual standard errors.

Finally, this study faces limitations in the approach used to examine differences by maternal age. Estimating a single model that interacts event-time dummies with age groups can produce biased estimates, as differential pre-trends or treatment effect heterogeneity across groups may distort the estimated coefficients. A more robust strategy would estimate separate event study models for younger and older mothers, as demonstrated by Lebedinski, Perugini and Vladisavljević (2022), which enables clearer identification of wage trends within each group.

6) Conclusion

Using a TWFE model, this study finds that each additional child is associated with an 11.1% decline in wages, consistent with existing UK-based research on the MWP (Trades Union Congress, 2016). This provides evidence that childbearing has a negative effect on women's earnings.

The event study findings indicate that first births are associated with larger and more persistent wage penalties, with a 14% decline in wages one year after birth compared to a 7.4% decline following second births. Robustness checks, including joint F-tests for parallel trends and placebo events, support the credibility of these estimates.

The analysis provides further evidence to reject the H_0 that wage trajectories are the same for first and second births. The larger and more sustained penalties following first births are consistent with the view that the initial transition into motherhood imposes greater career disruption, compared to subsequent births.

When exploring the MWP by age group the study finds that younger mothers experience descriptively larger wage reductions. However, statistical tests do not provide sufficient evidence to reject the H_0 that wage trajectories are the same across age groups.

This research highlights the need for greater support for mothers in the UK labour market to address persistent wage penalties. Continued efforts are required to better understand the drivers of the MWP, including workplace discrimination and the lack of affordable childcare. Further initiatives should focus on extending support for mothers beyond maternity leave, addressing the limitations of short-term childcare solutions, and promoting longer-term family friendly employment practices.

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Appendix

A1:

Variable	**Description**
Wages	Total monthly gross income (log-transformed)
Number of children	Number of own children in household
Event-time dummies (First Birth)	Dummies for each year where $-3 \leq t \leq +4$, relative to first birth ($t = 0$)
Event-time dummies (Second Birth)	Dummies for each year where $-3 \leq t \leq +4$, relative to second birth ($t = 0$)
Older mother	1 = Aged 35-46 at childbirth, 0 = Otherwise
Younger mother	1 = Aged 18-34 at childbirth, 0 = Otherwise
Partnership status	1 = Partnered, 0 = Single
Use of childcare	1 = Uses childcare, 0 = Does not use childcare
Urban/rural residence	1 = Urban, 0 = Rural
Highest qualification	Categorical: 1 = Degree, 2 = Other Higher, 3 = A-level, 4 = GCSE, 5 = Other, 9 = None

A2:

Variable	Statistic	First-Birth	Second-Birth
Wages	Mean (SD)	£1,725.90 (1,000.10)	£1,843.00 (1,117.90)
Age	Mean (SD)	31.5 (5.0)	35.2 (5.0)
Partnered	% Yes / No	89.01% / 10.99%	92.12% / 7.88%
Childcare	% Yes / No	19.34% / 80.66%	21.46% / 78.54%
Urban/Rural	% Yes / No	76.35% / 23.65%	77.12% / 22.88%
Age Group	% Older / Younger	77.72% / 22.28%	56.90% / 43.10%

A3[5]:

	hiqual_1	hiqual_2	hiqual_3	hiqual_4	hiqual_5
hiqual_1	1.000	-0.414	-0.519	-0.385	-0.117
hiqual_2	-0.414	1.000	-0.196	-0.146	-0.044
hiqual_3	-0.519	-0.196	1.000	-0.183	-0.056
hiqual_4	-0.385	-0.146	-0.183	1.000	-0.041
hiqual_5	-0.117	-0.044	-0.056	-0.041	1.000

[5] Pearson correlation coefficients are shown, all significant at the 1% level. Shading indicates correlation strength and direction, with darker hues representing stronger negative values