After the Shock
Reform, Resilience, and Economic Transformation in MENA
ERF 32nd Annual Conference
June 14-16 | Cairo, Egypt

2026

The Sibling Penalty:

Unequal Gendered Effects of Childbirth on Sibling's Time Allocation

Javad Dashtimanesh,
Mohammad Vesal
and Javad Shaker Arani

ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية

The Sibling Penalty: Unequal Gendered Effects of Childbirth on Sibling's Time Allocation*

Javad Dashtimanesh † Mohammad Vesal‡ Javad Shaker Arani §

December 1, 2025

Abstract

This paper studies how childbirth reshapes intra-household time allocation in Iran, with a focus on older children. Using the Iranian Time Use Survey, we combine 24-hour time diaries with information on household structure and apply a pseudo event–study design. First, we document large gender gaps in unpaid work: women devote substantially more time than men to caregiving and home production, while men work more in the market. Around the birth of the youngest child, mothers increase caregiving and home production and reduce paid work, whereas fathers mainly adjust by raising paid work hours. We then show that part of the additional care burden is absorbed by older daughters. Following the arrival of a younger sibling, daughters increase caregiving and home services more than sons and reduce leisure time. We interpret this pattern as evidence of a sibling penalty in time use.

*This is an early draft of ongoing research, and certain sections are not yet fully developed.

†Ph.D. candidate, Sharif University of Technology, dashtimanesh@gsme.sharif.edu

‡Associate professor, Sharif University of Technology, m.vesal@sharif.edu

§Independent Researcher, mjshaker1372@gmail.com

1 Introduction

Time is the fundamental scarce resource within households. A long tradition in economics studies how families allocate time between market work, home production, and leisure, and how this allocation responds to wages, prices, and policies (Becker 1965; Gronau 1977). Within these models, childbirth is a central event: it generates a sudden increase in the demand for childcare and typically reshapes who does what inside the family. Recent work has documented sizeable and persistent "child penalties" in women's labour market outcomes following childbirth, with much smaller effects for men (Kleven, Landais, and Søgaard 2019; Kleven, Landais, and Søgaard 2021; Kleven 2022; Kleven, Landais, and Leite-Mariante 2025; Kleven, Landais, Posch, et al. 2024). These studies show that mothers reduce labour supply and earnings for many years, while fathers' trajectories are largely unchanged or even improve.

The allocation of unpaid work within the household is a key channel behind these child penalties. In many countries, women perform a disproportionate share of domestic and caregiving tasks, even when they are employed (Attanasio, Low, and Sánchez-Marcos 2008; Greenwood et al. 2016; Balbo et al. 2024; Brito and Contreras 2024; Casarico, Del Rey, and Silva 2023). These patterns are closely tied to social norms about gender roles in the home and the labour market (Alesina, Giuliano, and Nunn 2013; Fernández 2013; Bertrand, Kamenica, and Pan 2015; Bursztyn, González, and Yanagizawa-Drott 2020). In middle–income settings with low female labour force participation, such as Iran, a large majority of working–age women are out of the labour force and report "personal and family responsibilities" as the main reason for not working. Understanding how these responsibilities are distributed inside the household, and how they change when a new child arrives, is therefore central to any account of gender inequality in economic outcomes.

While the literature has focused mainly on mothers and fathers, childbirth may also affect the time allocation of other family members. A growing body of work shows that grandparents' childcare can facilitate mothers' employment (Posadas and Vidal-Fernandez

2013; Yamamura and Ohtake 2024), and that older siblings — especially sisters — sometimes provide informal childcare with potential consequences for their own schooling (Jakiela et al. 2020). However, we know relatively little about the systematic role of older sons and daughters in absorbing the additional care and domestic workload generated by a new birth, particularly in settings with strong gender norms and limited formal childcare. In such contexts, older daughters may be seen as a natural source of flexible, low–cost care, potentially creating a "sibling penalty" in their own time use and human capital investment.

This paper studies how childbirth affects intra–household time allocation across parents and older children in Iran, with a particular focus on gender differences. We use micro data from three waves of the Iranian Time Use Survey (ITUS) — a nationally representative survey with detailed 24–hour diaries for household members — to document patterns of daily time use and to estimate the dynamic response of different activities to the age of the youngest child. Our empirical strategy adapts the pseudo event–study approach proposed by Kleven (2022) to a setting where individuals are observed once in cross–section but can be linked to the age structure of their household. By combining observed post–birth outcomes with synthetic pre–birth outcomes constructed from a carefully matched control pool, we recover event–time profiles for mothers, fathers, sons, and daughters in a common framework.

The paper makes three contributions. First, we provide new descriptive evidence on gendered time allocation in Iran. Using the ITUS diary data, we show that women devote substantially more time than men to caregiving and home production, while men spend more time in paid work. Similar, though smaller, gaps appear among children: daughters contribute more to domestic work and caregiving than sons and spend somewhat less time in learning activities. These stylised facts indicate that gendered specialisation in household production emerges already in childhood, well before entry into the labour market.

Second, we quantify how childbirth reshapes adults' time allocation. The pseudo–event study estimates for parents are consistent with the child–penalty literature. Around the birth of the youngest child, mothers sharply increase caregiving and home production and

reduce paid work, while fathers adjust primarily along the paid–work margin. For mothers, these changes are sizable and persist for many years as the youngest child ages. For fathers, the increase in paid work is more moderate, and their unpaid work changes little. We also document how these adjustments are financed by reductions in leisure, self–care, and communication, especially for mothers.

Third, we examine the response of older children and introduce the concept of a "sibling penalty" in time use. Following the birth of a younger child, older daughters increase caregiving and home production more than sons and reduce time spent in learning and leisure by more. In our preferred specifications, we find that daughters' caregiving rises by roughly 1–1.5 hours per day in the years immediately after birth, and their learning time falls by a similar order of magnitude. Sons' time use changes in the same qualitative direction but by smaller amounts and with more recovery over time. These child–level estimates are subject to greater sampling uncertainty than the adult estimates, particularly for subgroups and later event years, so the magnitudes should be interpreted with appropriate caution. Nonetheless, the overall pattern is consistent with the idea that part of the care burden generated by childbirth is shifted onto older daughters.

We also explore heterogeneity by maternal employment status. One might expect that when mothers are employed — and thus more time–constrained — older daughters substitute more strongly into caregiving. Alternatively, employed mothers may have better access to formal childcare, weakening the reliance on daughters. Our results suggest that the qualitative pattern of a sibling penalty is present in both groups: daughters with employed and non–employed mothers increase caregiving and home services after a younger sibling is born. The composition of the adjustment, however, differs somewhat. In households where the mother is not in paid work, the point estimates indicate larger reductions in daughters' leisure and, to a less precisely estimated extent, learning time, whereas for daughters with employed mothers, the evidence for a systematic effect on learning is weaker.

Our findings relate to several strands of the literature. They connect the child–penalty

literature on mothers' labour market trajectories with research on informal care and intergenerational transfers within families (Posadas and Vidal-Fernandez 2013; Yamamura and Ohtake 2024; Jakiela et al. 2020). They also speak to dynamic models of household labour supply and home production over the life cycle (Attanasio, Low, and Sánchez-Marcos 2008; Greenwood et al. 2016; Iiboshi, Yoshii, and Ozaki 2024) and to work on the origins and persistence of gender norms (Alesina, Giuliano, and Nunn 2013; Fernández 2013; Bertrand, Kamenica, and Pan 2015; Bursztyn, González, and Yanagizawa-Drott 2020). By focusing on a middle–income country with low female labour force participation and strong family roles, we complement existing evidence that comes primarily from high–income settings.

The rest of the paper is organised as follows. Section 2 describes the Iranian Time Use Survey, the construction of activity categories, and the household samples used in the analysis. Section 3 documents stylised facts on daily time allocation by gender, employment status, and child status. Section 3 presents a simple conceptual framework that organises our thinking about intrahousehold time allocation and the role of gender norms. Section 5 outlines the pseudo event–study design. Section 6 reports the main empirical results for parents and older children, including heterogeneity by maternal employment. Section 6 concludes and discusses implications for policies aimed at easing childcare constraints and promoting more equitable time allocation within families.

2 Data

2.1 Iranian Time Use Survey

We use micro data from the Iranian Time Use Survey (ITUS), a nationally representative time–use survey conducted in three waves: 2008–09, 2014–15, and 2019–20. Each wave runs from autumn of year t to summer of year $t+1$. Interviews are carried out at the end of each season, which spreads observation days across the calendar year and reduces concerns about seasonality in time allocation.

The survey is organised at the household level. In the most recent wave (2019–20), the sample covers 12,994 households and 41,709 household members, of whom 31,901 completed the time–use diary. Earlier waves have similar designs but somewhat smaller samples. For each participating individual, the ITUS collects a detailed 24–hour diary for the preceding day, together with standard demographic and labour–market information.

2.2 Time–Use Diary and Activity Measures

The diary records activities in 15–minute intervals over a full 24–hour period. For each interval, respondents report:

1. what they were doing (primary activity),
2. what else they were doing (secondary activity, if any),
3. where they were, and
4. who they were with.

We use the primary activity codes to construct mutually exclusive and exhaustive categories that align with standard models of household time allocation. Specifically, we focus on:

- *paid work*: market work and commuting;
- *home production and unpaid domestic work*: cooking, cleaning, household maintenance, and similar tasks;
- *caregiving*: care for children and other dependents;
- *learning*: schooling, homework, and other educational activities;
- *other non–market activities*: self–care, leisure, and social or religious participation.

For each individual, we aggregate minutes spent in each category over the day. These variables form the outcome vector Y_i in the descriptive analysis and in the pseudo event–study regressions described in Section 5.

2.3 Household Structure and Youngest Child

The ITUS household roster identifies every co–resident member's age, gender, and relationship to the household head. We use this information to reconstruct family structure and to locate individuals within the household (mother, father, son, daughter).

For each household h, we denote the set of ages of co–resident children by $\{\text{age}_{ch}\}$ and define the age of the youngest child as

$$\text{youngest\_child}_h \equiv \min\{\text{age}_{ch}\}.$$

We also compute the total number of children in the household, which we interpret as household parity. Combining these variables with individual identifiers allows us to link every adult or older child i to the age of the youngest co–resident child in her household, youngest_child_h, which later serves as the event–time variable in our research design.

2.4 Sample Construction

Our starting point is all individuals who completed the time–use diary and live in households with at least one child. From this universe we construct two main analytic samples.

First, for the descriptive "stylised facts" we retain all household members and document average daily time allocation by gender and household role (men versus women; employed versus unemployed; sons versus daughters). These patterns provide a baseline picture of the gendered division of labour in Iran.

Second, for the causal analysis we focus on adults aged 15 and above living in households whose youngest child is at most 10 years old. These adults constitute the treated population

in our pseudo event–study design. For each such adult i, we observe time use at an event time

$$\tau_i = \text{youngest\_child}_h \in \{0, 1, \ldots, 10\},$$

defined by the age of the youngest child. As detailed in Section 5, we complement these post–birth observations with synthetic pre–event outcomes constructed from a control pool of adults without young children, matched on age, gender, and parity. The resulting pseudo–panel allows us to trace how childbirth reshapes time allocation for mothers, fathers, sons, and daughters within the same empirical framework.

3 Stylized Facts

Before turning to the causal research design, we document a set of descriptive patterns on how Iranians allocate their time over the day and across broad activity categories. These stylized facts provide context for our later analysis of how childbirth reshapes time use within the household.

3.1 Daily Time Allocation by Gender

Figure 1 plots the distribution of time use over the 24–hour day for men and women. For each hour, the graphs report the share of time spent in paid work, home services and unpaid domestic work, caregiving, culture and leisure, self–care, communication and religion, and other residual activities.

Two features stand out. First, paid work follows a pronounced "working–day hump" for men, with a large share of time devoted to market work between roughly 8:00 and 18:00. For women, the corresponding hump is much smaller, and a substantial part of the working day is instead allocated to home services and caregiving. Second, women spend more time in caregiving and other unpaid work not only during standard working hours but also in the early morning and late evening, while men devote a larger fraction of off–work time

to leisure. These patterns are consistent with a gendered division of labour in which men specialise in market work and women specialise in domestic production and care.

3.2 Employment Status and Time Use

Figure 2 splits the adult population by employment status. Among employed men, paid work dominates the working day, and time spent on home services and caregiving remains limited throughout the day. Employed women also exhibit a clear paid–work hump, but their hours in home services and caregiving remain high relative to employed men, indicating a double burden of market work and domestic responsibilities.

Among the unemployed, the contrast between men and women is even sharper. Unemployed men allocate a sizable part of the day to leisure and self–care, with relatively modest contributions to home services or caregiving. Unemployed women, by contrast, devote a large fraction of daytime hours to home production and caregiving activities. Thus, even when not employed in the labour market, women shoulder most of the unpaid work within the household.

3.3 Children's Time Use: Sons versus Daughters

Figure 3 reports the daily time profiles for boys and girls. Both groups spend the core school hours in learning activities, as expected. However, outside of school time, girls allocate more time to home services and caregiving than boys, who devote more time to leisure and other non–market activities. The gap is most pronounced in the late afternoon and evening, when girls' contributions to domestic work and care intensify.

These patterns suggest that gendered specialisation in domestic tasks emerges already in childhood, well before entry into the labour market. In the next sections we show that the arrival of a younger sibling amplifies these differences, especially for older daughters.

3.4 Total Daily Minutes by Group

Finally, Figure 4 summarises total minutes per day spent in different activity categories for key demographic groups: all men, all women, employed and unemployed adults by gender, and sons and daughters. Women, on average, spend substantially more time in caregiving and home services than men, while men devote more time to paid work. Among children, daughters contribute more to caregiving and unpaid work than sons and spend somewhat less time in learning.

Taken together, these stylized facts highlight three important points. First, there is a large and systematic gender gap in unpaid domestic work among adults. Second, this gap persists even among the unemployed, suggesting that it is not solely driven by time constraints from market work. Third, similar gender gaps appear among children, with girls already contributing more to household production than boys. These descriptive regularities motivate our focus on how childbirth affects time allocation within the family and, in particular, on the "sibling penalty" borne by older daughters.

4 Conceptual Framework

We consider a household with four members: a mother m, a father f, an older daughter d, and an older son b. Each individual has a fixed time endowment T per day that can be allocated to market work, childcare, leisure, and, for children, education or learning activities. The arrival of a new child increases the household's demand for childcare, and the key question is how this additional care requirement is allocated across family members and how it affects the older daughter's time use.

4.1 Household Environment

For each member $g \in \{m, f, d, b\}$, let n_g denote time spent in market work, h_g time spent in childcare for the youngest child, l_g leisure, and for children $c \in \{d, b\}$, e_c time devoted to

education and learning. The individual time constraint is

$$T = n_g + h_g + l_g + \mathbf{1}\{g \in \{d, b\}\}e_g \quad \forall g \in \{m, f, d, b\}. \tag{1}$$

Household consumption C is financed by labor income and exogenous non-labor income Y:

$$C = w_m n_m + w_f n_f + w_d n_d + w_b n_b + Y, \tag{2}$$

where w_g denotes the market wage of member g. In practice, w_d and w_b are low or zero for school-aged children, but we keep them in the notation for generality.

Effective childcare Q is produced by combining time inputs from different household members and possibly market childcare services s:

$$Q = a_m h_m + a_f h_f + a_d h_d + a_b h_b + a_s s, \tag{3}$$

where $a_g > 0$ captures the productivity of each member in providing childcare and a_s the productivity of market care. Market childcare is purchased at price p_s per unit of s.

4.2 Childbirth and Childcare Requirements

Let y denote the age of the youngest child in the household. The household faces a childcare requirement $\overline{q}(y)$ that is high when the youngest child is a newborn and declines with age:

$$\overline{q}'(y) < 0. \tag{4}$$

A birth increases the required care level, represented as a discrete upward shift in $\overline{q}(y)$ at $y = 0$. We impose a technological or institutional constraint that effective care must cover this requirement:

$$Q \geq \overline{q}(y). \tag{5}$$

Equivalently, we can write the problem with a penalty function $\Phi(\overline{q}(y) - Q)$, where $\Phi(\cdot)$ is convex and increasing in shortfalls, so that any failure to meet $\overline{q}(y)$ is costly.

4.3 Preferences and Gender Norms

The household maximizes a common utility function that depends on consumption, leisure, children's education, and the disutility of providing care:

$$U = u(C) + \sum_{g \in \{m,f,d,b\}} \nu_g v(l_g) + \theta_d \psi(e_d) + \theta_b \psi(e_b) - \sum_{g \in \{m,f,d,b\}} \pi_g(h_g), \tag{6}$$

where $u(\cdot)$, $v(\cdot)$, and $\psi(\cdot)$ are increasing and concave. The parameters ν_g measure the weight on leisure for each member, and θ_c the value placed on child c's education.

The functions $\pi_g(h_g)$ capture the (possibly norm-driven) cost of allocating childcare time to member g. A simple specification is linear costs,

$$\pi_g(h_g) = \tau_g h_g, \tag{7}$$

where $\tau_g \geq 0$ represents an additional "norm cost" per unit of care time. Gender norms can be represented by τ_d being relatively low (care is considered appropriate for daughters) and τ_b relatively high (care is considered less appropriate for sons). Similarly, the relative size of τ_m and τ_f can capture norms about maternal versus paternal involvement in childcare.

The household chooses $\{n_g, h_g, l_g, e_d, e_b, s\}$ to maximize U subject to the time constraints, the budget constraint, and the childcare requirement.

4.4 Optimal Care Allocation

With a hard childcare constraint $Q \geq \overline{q}(y)$, let $\mu \geq 0$ denote the Lagrange multiplier (shadow cost) on this constraint. The first-order conditions for h_g (using $\pi_g'(h_g) = \tau_g$) can be written

as

$$\nu_g v'(l_g) + \tau_g = \mu a_g \quad \forall g \in \{m, f, d, b\}. \tag{8}$$

This condition states that the marginal utility cost of reallocating one unit of time from leisure to childcare for member g — the sum of forgone leisure $\nu_g v'(l_g)$ and norm cost τ_g — must equal the shadow price of effective care, scaled by the member's care productivity a_g.

Similarly, the first-order conditions for the children's education time e_c are

$$\theta_c \psi'(e_c) = \nu_c v'(l_c) \quad \text{for } c \in \{d, b\}, \tag{9}$$

reflecting the trade-off between education and leisure for each child. The conditions for market work n_g equate the marginal utility of consumption from an additional unit of labor income to the marginal disutility of reducing leisure.

Taken together, these conditions imply that care is allocated to the member with the lowest "effective cost" per unit of effective childcare:

$$\text{Effective cost}_g = \frac{\nu_g v'(l_g) + \tau_g}{a_g}. \tag{10}$$

For a given shadow price μ, the household increases h_g for those members with low effective cost and reduces it for those with high effective cost.

4.5 Birth Shock and the Sibling Penalty

A birth increases the required care $\overline{q}(y)$ and thus the shadow price μ. To satisfy the higher care requirement, the household must raise Q, which is achieved by increasing h_g for members with the lowest effective cost. Under plausible assumptions for a setting with traditional gender norms:

- The daughter's wage w_d is low, and her care productivity a_d is relatively high.
- The norm cost τ_d is low, while τ_b is high for the son.

- The mother's care productivity a_m is high, but her labor supply has a meaningful impact on household income if w_m is positive.

In such a setting, the additional childcare requirement after childbirth is met primarily by increasing h_m (mother) and h_d (older daughter), while h_b remains small. Because the daughter faces the same time constraint,

$$T = n_d + h_d + l_d + e_d, \tag{11}$$

an increase in h_d must come at the expense of some combination of e_d and l_d (and possibly n_d if she works). If the household values her education but treats her time as relatively cheap for care, the model predicts that a non-trivial share of the additional care burden is financed by a reduction in e_d.

We refer to this reduction in learning time following a sibling's birth as the *sibling penalty*. It arises not because the daughter has a child herself, but because the household uses her time to absorb the increased care demand created by a newborn.

4.6 Comparative Statics

The framework yields several comparative statics that map directly into our empirical analysis:

- **Care substitution.** A higher childcare requirement $\overline{q}(y)$ (e.g., when the youngest child is very young) increases the shadow price μ and raises the demand for low-cost care providers. If

$$\frac{\nu_d v'(l_d) + \tau_d}{a_d} < \min\left\{\frac{\nu_m v'(l_m) + \tau_m}{a_m}, \frac{\nu_f v'(l_f) + \tau_f}{a_f}, \frac{\nu_b v'(l_b) + \tau_b}{a_b}, \frac{p_s}{a_s}\right\},$$

  then the marginal care unit is allocated to the daughter, implying h_d increases with the birth and with the level of care required for young children.

- **Sibling penalty in education.** Given the daughter's time constraint, an increase in h_d leads to a reduction in e_d, holding n_d and T fixed. Therefore, the model predicts a decline in daughters' learning or education time when the youngest sibling is young, while the corresponding effect on sons' education time is limited if τ_b is high.

- **Gendered labor supply responses.** If the mother's market wage w_m is sufficiently high, the birth also triggers an adjustment in parental labor supply: mothers reduce n_m to provide more childcare, while fathers may increase n_f to stabilize household income. This generates a traditional "child penalty" for mothers and a complementary increase in fathers' labor.

- **Policy counterfactuals.** Policies that relax mothers' time constraints or reduce the effective cost of non-family care — such as shorter working hours with full pay, subsidized childcare, or after-school programs — lower the effective cost of care provision by adults or the market. In the model, this reduces the need to rely on the daughter's time, decreasing h_d and mitigating the sibling penalty on e_d.

In the empirical sections below, we test these implications by tracking changes in time allocation across mothers, fathers, daughters, and sons as a function of the age of the youngest child in the household. The model provides a simple organizing framework for interpreting the observed patterns as the outcome of intrahousehold time allocation under gendered norms and binding childcare requirements.

5 Research Design

5.1 Pseudo Event–Study Approach

Our objective is to identify how childbirth reshapes adults' time use, despite the absence of panel data. A conventional event–study requires observing the same individual before and after the birth of a child. Instead, we work with repeated cross–sections in which each

adult is interviewed once but reports detailed information on all co–resident children together with a 24–hour time–use diary. To recover event–time dynamics in this setting, we employ a pseudo event–study design following Kleven (2022), adapting it to the context of household fertility and intrafamily time allocation.

5.1.1 Event Definition and Treated Sample

Let i index adults and h their households. For each household, we observe the age of every co–resident child and define

$$\text{youngest\_child}_h \equiv \min\{\text{age of co–resident children}\}.$$

We define a treated household as one with at least one child aged 0–10. Our treated sample consists of adults aged 15 or older living in such households. For each adult i in a treated household, we define the *event time*

$$\tau_i = \text{youngest\_child}_h \in \{0, 1, \ldots, 10\},$$

where $\tau_i = 0$ corresponds to the birth year of the youngest child, $\tau_i = 1$ corresponds to the next year, and so forth. Let Y_i denote a time–use outcome (paid work, caregiving, home production, learning, leisure, etc.), constructed from diary categories `perios_1`–`perios_9`. We estimate event–time profiles separately for men and women.

5.1.2 Control Pool and Synthetic Pre–Event Outcomes

Because each adult is observed only once, the same treated individual is never observed before childbirth. To recover pre–event outcomes, we construct *synthetic* pre–event observations from a control pool of adults who have no children aged 0–10. This pool includes adults in childless households or households with only older children. For each control adult j, we retain their observed time use Y_j, age, gender, survey year, and total number of children in

the household.

We then focus on treated adults at $\tau_i = 0$. For each such adult we observe their age A_i, gender G_i, and total number of children in the household, denoted kid_counter_all_h. Under the assumption of single births, the number of children *before* the newborn is

$$\text{parity}_i^{\text{pre}} = \text{kid\_counter\_all}_h - 1.$$

We generate $K = 4$ synthetic pre–event periods $\tau = -1, -2, -3, -4$ by mechanically shifting age backward:

$$A_{i,\tau} = A_i + \tau, \qquad \tau \in \{-4, -3, -2, -1\},$$

dropping cells where $A_{i,\tau} < 15$. Each synthetic observation (i, τ) is then matched to all controls j who share

$$A_j = A_{i,\tau}, \qquad G_j = G_i, \qquad \text{parity}_j = \text{parity}_i^{\text{pre}},$$

and, by construction, have no young children. Let $\mathcal{C}(i, \tau)$ denote the set of matched controls. The synthetic counterfactual outcome is defined as

$$\tilde{Y}_{i\tau} = \frac{1}{|\mathcal{C}(i,\tau)|} \sum_{j \in \mathcal{C}(i,\tau)} Y_j, \tag{12}$$

which estimates the time–use pattern the treated adult would have exhibited in the absence of childbirth.

Stacking these synthetic pre–event records with the observed post–event records $\tau \in \{0, \ldots, 10\}$ yields a pseudo–panel with one observation per adult for each event time $\tau \in \{-4, \ldots, 10\}$:

$$Y_{i\tau}^* = \begin{cases} \tilde{Y}_{i\tau}, & \tau < 0, \\ Y_i, & \tau \geq 0. \end{cases}$$

Identification relies on a conditional parallel–trends assumption: conditional on age, gender, and parity, adults who are about to have a newborn would have had the same time–use trajectory as otherwise similar adults without a young child. Under this assumption, $\tilde{Y}_{i\tau}$ forms a valid counterfactual for untreated potential outcomes.

5.1.3 Event–Study Specification

We estimate the following event–study regression for each outcome Y and gender $g \in \{\text{men}, \text{women}\}$:

$$Y_{i\tau}^{*,g} = \sum_{\kappa=-4}^{10} \beta_{\kappa}^{g} \mathbf{1}\{\tau = \kappa\} + \phi_{A_i}^{g} + \psi_{\text{year}}^{g} + \varepsilon_{i\tau}^{g}, \tag{13}$$

where $\mathbf{1}\{\tau = \kappa\}$ is an event–time indicator, $\phi_{A_i}^{g}$ and ψ_{year}^{g} denote age and survey–year fixed effects, and $\varepsilon_{i\tau}^{g}$ is an error term. We omit $\tau = -1$ so that all coefficients are interpreted relative to the final pre–birth year.

Equation (13) is estimated separately across time–use categories. The coefficients β_{κ}^{g} trace the evolution of each activity around childbirth. For selected outcomes, we additionally compute the gender difference

$$\Delta_{\kappa} = \beta_{\kappa}^{\text{women}} - \beta_{\kappa}^{\text{men}},$$

which we interpret as a *child penalty* in that category of time use.

6 Results

This section presents the pseudo event–study estimates from equation (13), describing how time use varies with the age of the youngest child in the household. Event time κ is defined by this age, and all coefficients are expressed relative to the year before birth ($\kappa = -1$). We first discuss adults, then older children, and finally heterogeneity by maternal employment. Throughout, figures display point estimates with 95% confidence intervals.

For most outcomes and groups, pre–event coefficients for $\kappa \leq -1$ are small in magnitude

and statistically imprecise. This absence of pronounced pre–trends is consistent with the identifying assumption that, conditional on age, parity, and survey year, adults in households that are about to experience a birth follow similar time–use trajectories as otherwise comparable adults without a young child.

6.1 Adults: Caregiving, Home Production, and Paid Work

Figure 5 reports the event–time profile for caregiving. For women, there is a clear increase in caregiving at $\kappa = 0$: the point estimate corresponds to roughly three additional hours per day relative to the year before birth. As the youngest child ages, caregiving gradually declines but remains above the pre–birth level throughout the observed post–event window. For men, caregiving also rises around birth, but the magnitude is considerably smaller (on the order of a few tens of minutes per day), and the coefficients become close to zero several years after birth.

The pattern for home services and unpaid domestic work, shown in Figure 6, is broadly similar. Women experience a noticeable and persistent increase in home services following childbirth, whereas the estimates for men are small and centred around zero, with no strong evidence of a systematic response. Together, these two sets of results indicate that the additional domestic and caregiving workload generated by childbirth is absorbed mainly by women.

Figure 7 presents the event–study estimates for paid work. Childbirth is associated with a reallocation of market hours across genders. For men, paid work increases around birth, with point estimates suggesting roughly one hour more per day in the years immediately after childbirth. For women, paid work declines by close to one hour per day at $\kappa = 0$ and remains below the pre–birth baseline for most of the post–event period. These patterns are in line with the child–penalty literature: mothers reduce their labour supply after childbirth, while fathers increase theirs.

Taken together, the adult results depict a familiar adjustment pattern. The arrival of a

child is followed by higher caregiving and home production for women, lower paid work for women, and higher paid work for men, with relatively limited changes in men's unpaid work. The magnitudes of these changes are substantial for mothers and more modest for fathers.

6.2 Adults: Reallocation of Non–Market Time

We next examine how non–market activities adjust around childbirth. Because total time is fixed, the increase in caregiving and home production must be financed by reductions in other uses of time.

Figure 8 shows the event–time profile for self–care (including sleep and personal maintenance). Both men and women reduce self–care time at the event of birth, with somewhat larger and more persistent declines for women. Figure 9 displays a similar pattern for leisure: leisure time falls around birth for both genders, with the decline more pronounced for women. Although there is some recovery as the youngest child ages, leisure for mothers remains below the pre–birth level through most of the post–event period.

Communication and social interactions, plotted in Figure 10, also decrease around childbirth. The point estimates indicate reductions of around one hour per day for both men and women at $\kappa = 0$, with somewhat larger declines for women in the early years after birth. These estimates suggest that parents partly accommodate the increase in caregiving by cutting back not only on leisure but also on social activities.

For religious activities and voluntary work (Figures 12 and 13), the estimated responses are small and imprecisely measured. Some coefficients fluctuate around zero with wide confidence intervals, and there is little evidence of large or systematic changes in these activities following childbirth.

Finally, Figure 11 reports event–time coefficients for learning and education among adults. Learning constitutes a small share of adults' daily time. The estimates point to modest reductions in learning in the years around childbirth, somewhat larger for women than for men, but the confidence intervals are relatively wide and do not always exclude zero.

These results suggest that the main adjustments in adult time allocation operate through caregiving, home production, paid work, leisure, self–care, and communication rather than adult learning.

Overall, the adult event–study results show a coherent reallocation of time following childbirth: women shift time from paid work and various forms of non–market time towards caregiving and home production, while men adjust primarily through changes in paid work and leisure.

6.3 Children: Sibling Penalty in Caregiving and Learning

We now turn to older children and examine how their time use changes when a younger sibling is born. Event time is again defined by the age of the youngest child, and we estimate separate event–time profiles for sons and daughters. Throughout this subsection, blue squares denote boys and red triangles denote girls.

For most activities, pre–event coefficients for $\kappa \leq -1$ are small and statistically imprecise for both sons and daughters, suggesting no strong differential trends prior to the birth of the younger sibling.

Caregiving and Home Services

Figure 14 reports the event–study estimates for caregiving time. Daughters increase their caregiving markedly at $\kappa = 0$: the point estimate corresponds to roughly 1–1.5 additional hours per day relative to the year before birth. The effect decreases over time as the youngest child grows older but remains positive for much of the post–event window. Sons also increase caregiving around birth, but the associated coefficients are smaller in magnitude and less precisely estimated.

A similar pattern appears in home services and unpaid domestic work (Figure 15). Daughters show a persistent rise in time devoted to home services after childbirth, whereas the estimates for sons are close to zero with wide confidence intervals. These results indicate

that, within the limits of sampling variability, a non–trivial share of the additional domestic and caregiving workload generated by childbirth is borne by older daughters rather than shared equally between sons and daughters.

Learning and Other Activities

Figure 20 examines time spent in learning and education. Both sons and daughters reduce learning time around the arrival of a younger sibling, but the decline is larger in the point estimates for daughters. For girls, learning falls by roughly 1–1.5 hours per day in the first years after birth and remains below the pre–birth level for much of the event window. For boys, the reduction is more modest and exhibits more recovery as the youngest child ages. At the same time, standard errors are sizeable, especially for daughters in later event years, so these differences should be interpreted as suggestive rather than definitive.

Leisure, self–care, and other non–market activities also adjust around childbirth. Figure 18 shows that leisure declines at $\kappa = 0$ for both sons and daughters, with larger negative coefficients for girls and partial recovery over time. Self–care (Figure 17) shows smaller and shorter–lived responses; the estimates point to modest reductions immediately after birth for both genders, again with relatively wide confidence intervals.

Communication and social interactions fall after childbirth for both sons and daughters (Figure 19), although the magnitude and precision of the estimates vary across event years. For religious activities and voluntary work (Figures 21 and 22), the estimated effects are generally small and imprecise, suggesting that these margins do not play a major role in absorbing the additional care burden.

Paid work among children is rare, and this is reflected in Figure 16: the coefficients are noisy and close to zero for both genders, with no clear systematic pattern.

In sum, the child–level event–study estimates are subject to greater sampling uncertainty than the adult estimates, particularly for subgroups and later event years. Nonetheless, the overall pattern is consistent with a *sibling penalty* concentrated on older daughters: following

the birth of a younger child, daughters increase caregiving and home production more than sons and reduce learning and leisure by more, while sons' time use changes relatively little.

6.4 Heterogeneity by Maternal Employment

The extent to which daughters absorb additional caregiving responsibilities may depend on whether the mother participates in the labour market. When the mother is employed, her time for caregiving is more constrained, which could increase the reliance on daughters. At the same time, employed mothers may have stronger labour market attachment and greater access to formal childcare, potentially mitigating the need to draw on daughters' time. To explore this dimension, we re–estimate the child–level event–study specification separately for girls with employed mothers and for girls whose mothers are not employed.

Figure 23 shows the impact of childbirth on caregiving time by maternal employment status. In both groups, caregiving rises at $\kappa = 0$ and then declines as the youngest child ages. Point estimates are somewhat larger for girls whose mothers are not employed, but confidence intervals are also wider, so differences between the two groups are not statistically sharp. Overall, the increase in caregiving following childbirth appears in both subgroups.

Time spent in home services and unpaid domestic work exhibits a comparable pattern (Figure 24). Girls with both employed and non–employed mothers increase their contribution to home services after a younger sibling is born, again with somewhat larger but less precisely estimated effects in households where the mother is not in paid work. These results suggest that daughters are drawn into domestic work irrespective of maternal employment, although the magnitude of the adjustment may differ.

Leisure and other non–market activities provide further evidence on how this adjustment is financed. Figure 27 indicates that leisure declines for both groups of girls around birth, with larger negative coefficients for those whose mothers are not employed. Self–care and communication (Figures 26 and 28) show smaller and more variable responses, and differences between the two groups are difficult to distinguish given the wide confidence intervals.

The learning estimates in Figure 29 point to heterogeneity in the *composition* of the sibling penalty. For girls with employed mothers, the event–time coefficients for learning fluctuate around zero and are generally imprecise, providing little evidence of a large and systematic effect on learning time. For girls whose mothers are not employed, the point estimates suggest a decline in learning in the early years after birth, although confidence intervals are wide and often include zero. Thus, the data are consistent with the possibility that education–related adjustments are more pronounced among girls in households where the mother is out of the labour force, but the evidence is not statistically conclusive.

Finally, for religious activities, voluntary work, and paid work (Figures 30, 31, and 25), the estimated effects are small and noisy for both groups, indicating that these margins play a limited role in the adjustment process.

Overall, the heterogeneity analysis suggests that maternal employment does not eliminate the sibling penalty: daughters in both types of households increase their caregiving and domestic work after the birth of a younger sibling. However, in households where the mother is not employed, the burden appears to be absorbed relatively more through reductions in daughters' leisure and, to a less precisely estimated extent, learning time.

7 Conclusion

This paper has examined how childbirth reshapes the allocation of time within Iranian households, using three waves of nationally representative time–use data and a pseudo event–study design. We first documented sizeable gender gaps in unpaid work: adult women devote much more time than men to caregiving and home production, while men spend more time in paid work. Around the birth of the youngest child, these gaps widen. Mothers increase caregiving and home services and reduce paid work, whereas fathers mainly respond by raising paid work hours and adjusting leisure, with limited change in their unpaid work.

We then extended the analysis to older children. The event–time profiles show that part of

the additional care burden generated by childbirth is absorbed by older daughters. Following the arrival of a younger sibling, daughters increase time spent in caregiving and home services more than sons and finance these changes primarily through reductions in leisure, and, to a less precisely estimated extent, learning. We interpret this pattern as evidence of a sibling penalty in time use: even though daughters do not have children themselves, their time is reallocated towards care when a new child enters the household.

Finally, we explored heterogeneity by maternal employment. Daughters in households with both employed and non–employed mothers increase their domestic and caregiving work after childbirth, suggesting that maternal employment does not eliminate the reliance on daughters' time. In households where the mother is not employed, the adjustment appears to operate relatively more through reduced leisure and possibly learning for girls, though estimates for learning are statistically imprecise.

The findings have two broader implications. First, they show that the child penalty in time use is not confined to mothers, but can extend to older daughters, who shoulder additional unpaid work and potentially sacrifice elements of their own human capital accumulation. Second, policies that relax parents' time constraints or lower the cost of formal childcare are likely to affect not only mothers' labour supply but also the intra–household distribution of care between parents and children. Future work could link time–use patterns to educational and labour–market outcomes to assess the long–run consequences of the sibling penalty, and compare the Iranian experience with other settings where gender norms and childcare institutions differ.

References

Alesina, Alberto, Paola Giuliano, and Nathan Nunn (2013). "On the origins of gender roles: Women and the plough". In: *The quarterly journal of economics* 128.2, pp. 469–530.

Attanasio, Orazio, Hamish Low, and Virginia Sánchez-Marcos (2008). "Explaining changes in female labor supply in a life-cycle model". In: *American Economic Review* 98.4, pp. 1517–1552.

Balbo, Nicoletta et al. (2024). "Heterogeneity in parental time with children: trends by gender and education between 1961 and 2012 across 20 countries". In: *European Sociological Review* 40.5, pp. 786–801.

Becker, Gary S (1965). "A Theory of the Allocation of Time". In: *The economic journal* 75.299, pp. 493–517.

Bertrand, Marianne, Emir Kamenica, and Jessica Pan (2015). "Gender identity and relative income within households". In: *The Quarterly Journal of Economics* 130.2, pp. 571–614.

Brito, Emilia and Dante Contreras (2024). "The caregiving penalty: Caring for sick parents and the gender pay gap". In: *Available here*.

Bursztyn, Leonardo, Alessandra L González, and David Yanagizawa-Drott (2020). "Misperceived social norms: Women working outside the home in Saudi Arabia". In: *American economic review* 110.10, pp. 2997–3029.

Casarico, Alessandra, Elena Del Rey, and Jose I Silva (2023). "Child care costs, household liquidity constraints, and gender inequality". In: *Journal of Population Economics* 36.3, pp. 1461–1487.

Fernández, Raquel (2013). "Cultural change as learning: The evolution of female labor force participation over a century". In: *American Economic Review* 103.1, pp. 472–500.

Greenwood, Jeremy et al. (2016). "Technology and the changing family: A unified model of marriage, divorce, educational attainment, and married female labor-force participation". In: *American Economic Journal: Macroeconomics* 8.1, pp. 1–41.

Gronau, Reuben (1977). "Leisure, home production, and work–the theory of the allocation of time revisited". In: *Journal of political economy* 85.6, pp. 1099–1123.

Iiboshi, Hirokuni, Yui Yoshii, and Daisuke Ozaki (2024). "Childcare, Time Allocation, and the Life Cycle: Estimation for Japanese Women". In: *Available at SSRN 5044514*.

Jakiela, Pamela et al. (2020). "Big sisters". In.

Kleven, Henrik (2022). *The geography of child penalties and gender norms: A pseudo-event study approach*. Tech. rep. National Bureau of Economic Research.

Kleven, Henrik, Camille Landais, and Gabriel Leite-Mariante (2025). "The child penalty atlas". In: *Review of Economic Studies* 92.5, pp. 3174–3207.

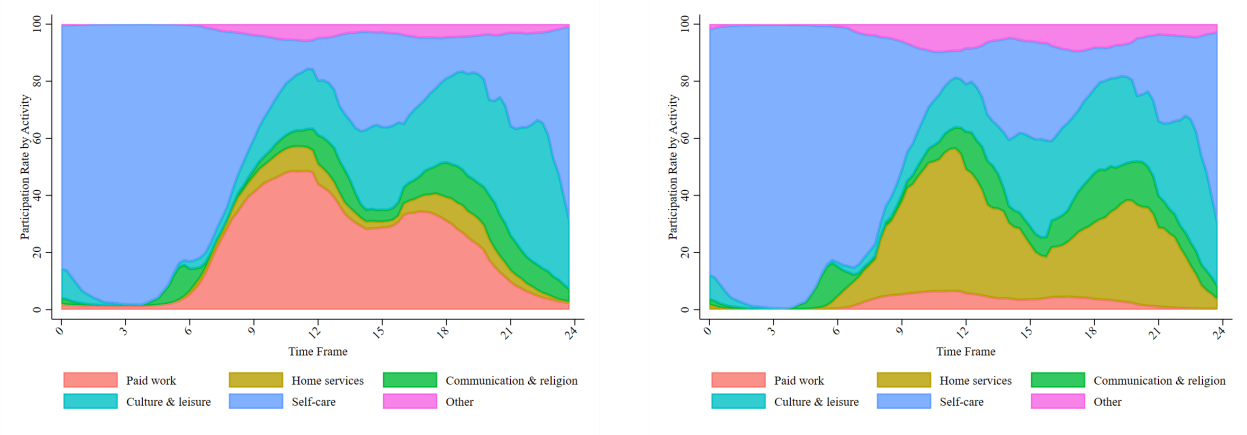
Kleven, Henrik, Camille Landais, Johanna Posch, et al. (2024). "Do family policies reduce gender inequality? Evidence from 60 years of policy experimentation". In: *American Economic Journal: Economic Policy* 16.2, pp. 110–149.

Kleven, Henrik, Camille Landais, and Jakob Egholt Søgaard (2019). "Children and gender inequality: Evidence from Denmark". In: *American Economic Journal: Applied Economics* 11.4, pp. 181–209.

— (2021). "Does biology drive child penalties? Evidence from biological and adoptive families". In: *American Economic Review: Insights* 3.2, pp. 183–198.

Posadas, Josefina and Marian Vidal-Fernandez (2013). "Grandparents' childcare and female labor force participation". In: *IZA Journal of Labor Policy* 2.1, p. 14.

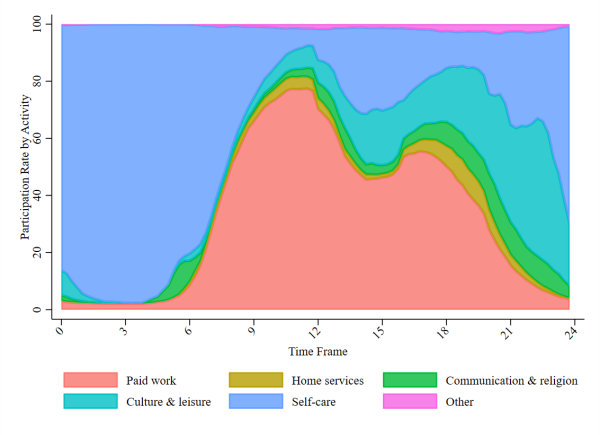
Yamamura, Eiji and Fumio Ohtake (2024). "Family structure, gender, and subjective well-being: effect of children before and after COVID-19 in Japan". In: *The Japanese Economic Review* 75.4, pp. 611–635.



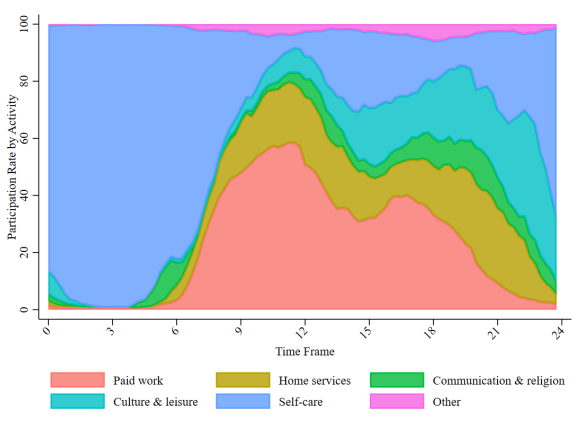
(a) Men

(b) Women

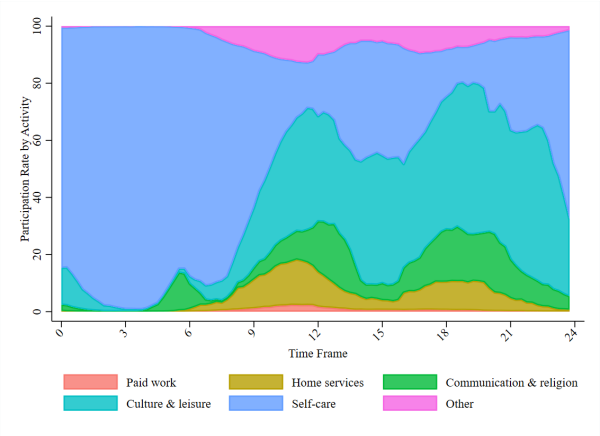
Figure 1: Daily time allocation by gender. Each panel plots the distribution of time across activity categories over the 24–hour day for adult men and women.



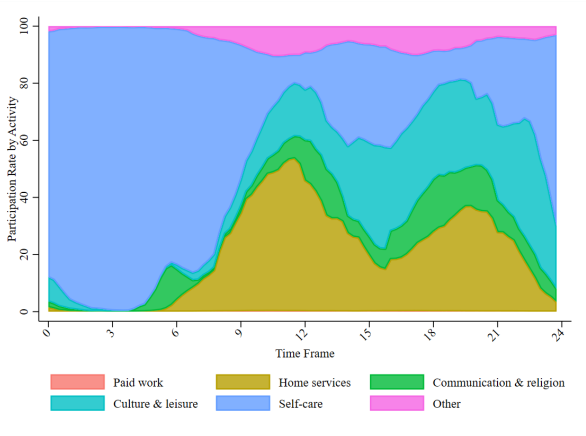
(a) Employed men



(b) Employed women

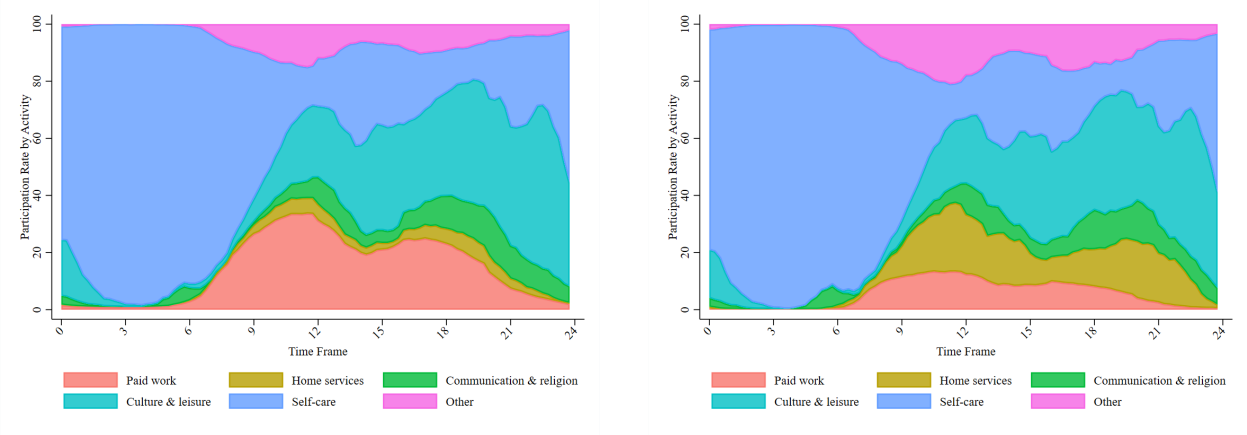


(c) Unemployed men



(d) Unemployed women

Figure 2: Daily time allocation by employment status and gender. Each panel shows the distribution of time across activity categories over the 24–hour day for employed and unemployed adult men and women.



(a) Boys (b) Girls

Figure 3: Daily time allocation for boys and girls. Each panel reports the distribution of time across activity categories over the 24–hour day for children.

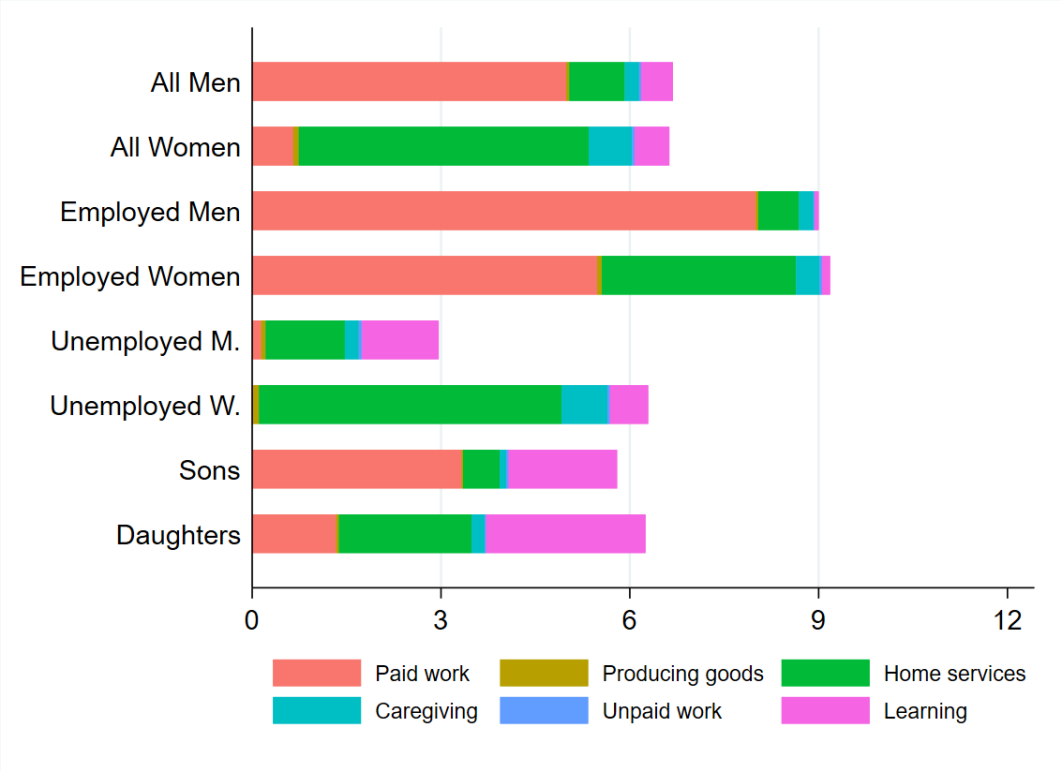


Figure 4: Total minutes per day spent in major activity categories for key demographic groups (all men, all women, employed and unemployed adults by gender, sons, and daughters).

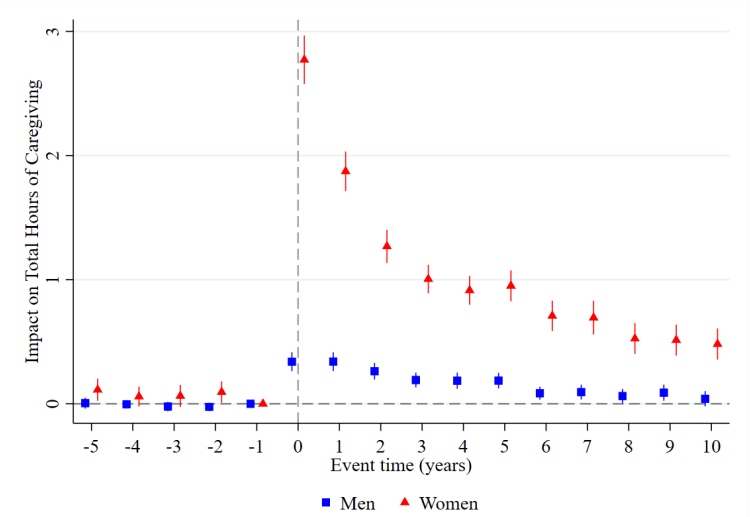


Figure 5: Impact of childbirth on caregiving time for men and women. Notes: Event–study coefficients from equation (13), with $\kappa = -1$ omitted as the reference period. Vertical bars denote 95% confidence intervals.

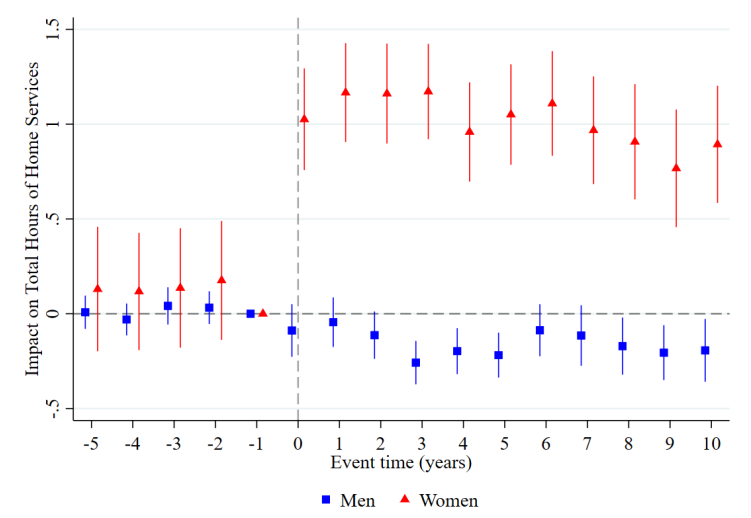


Figure 6: Impact of childbirth on time spent in home services and unpaid domestic work for men and women.

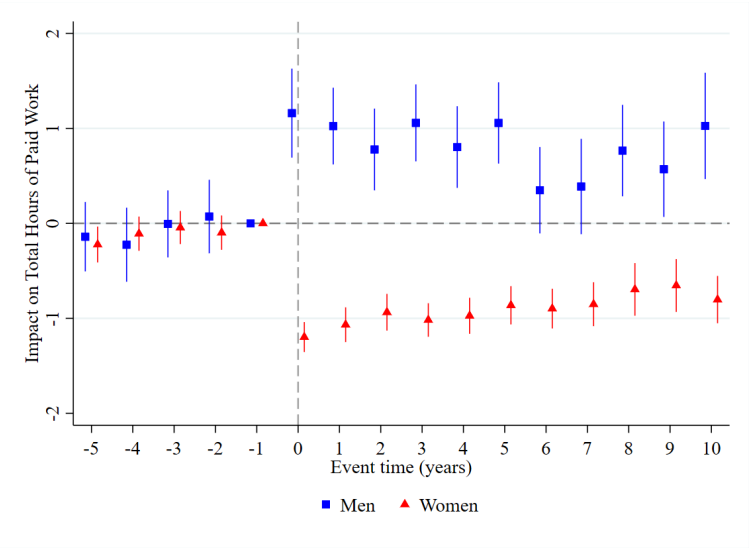


Figure 7: Impact of childbirth on paid work for men and women.

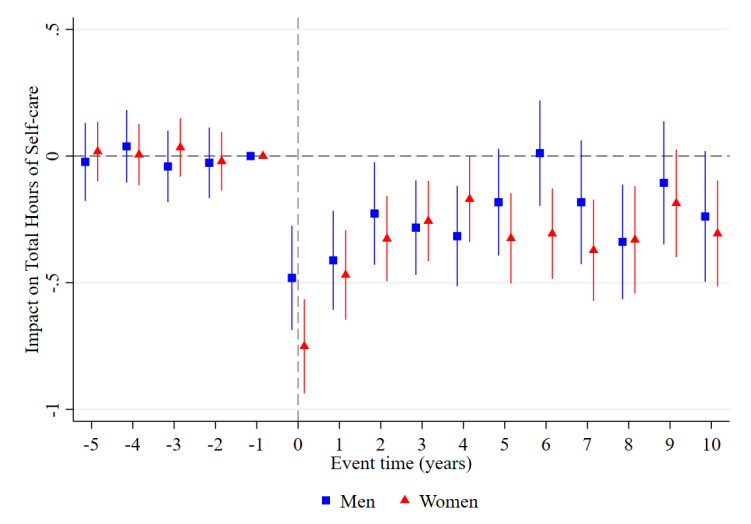


Figure 8: Impact of childbirth on self–care time for men and women.

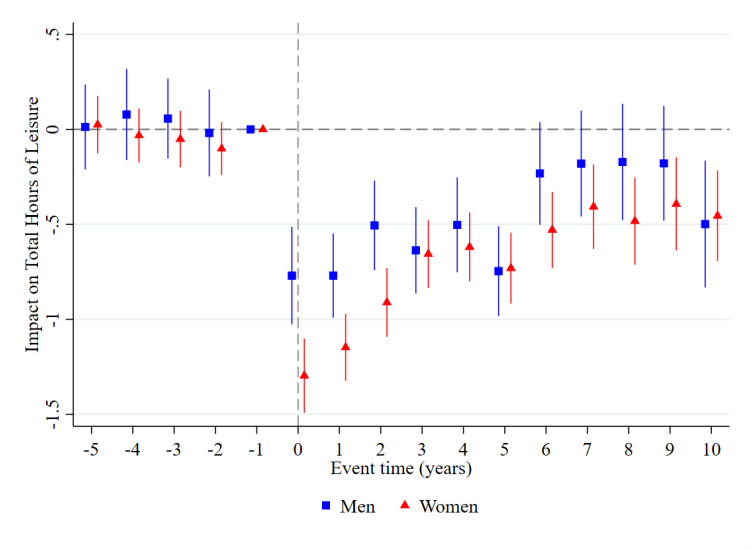


Figure 9: Impact of childbirth on leisure time for men and women.

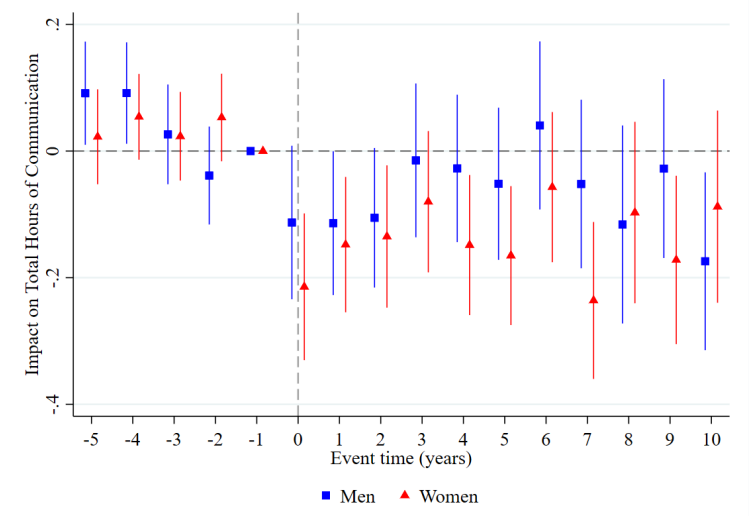


Figure 10: Impact of childbirth on time spent in communication and social interactions for men and women.

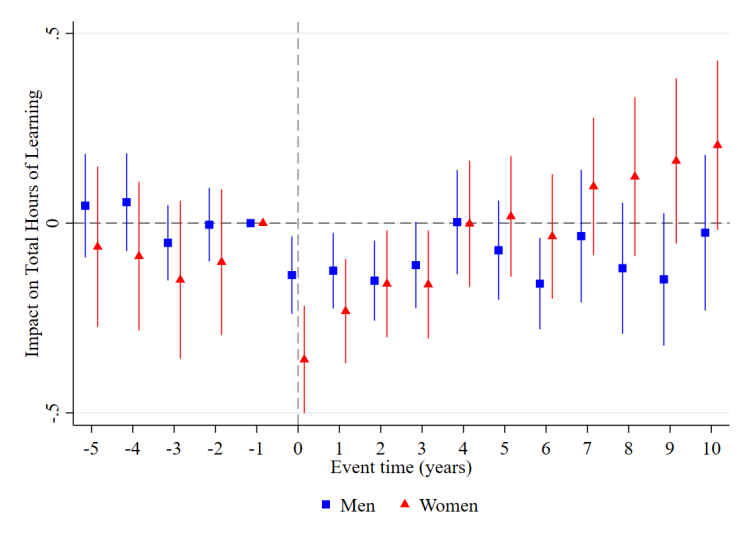


Figure 11: Impact of childbirth on time spent in learning and education for men and women.

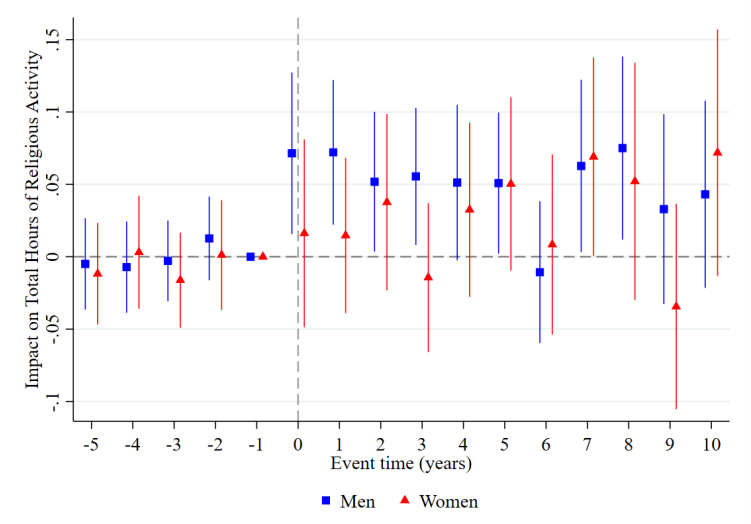


Figure 12: Impact of childbirth on time spent in religious activities for men and women.

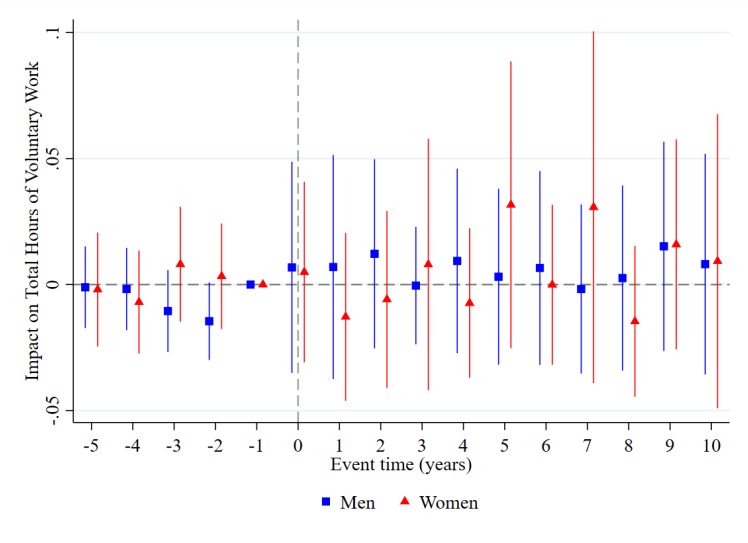


Figure 13: Impact of childbirth on voluntary work for men and women.

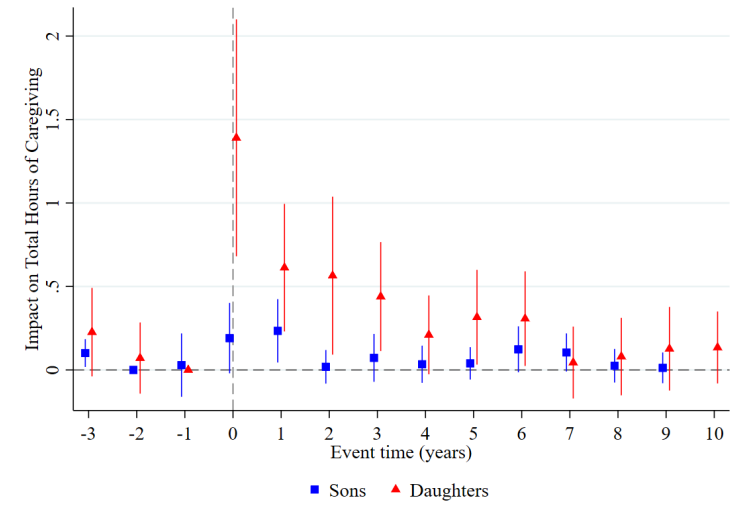


Figure 14: Impact of childbirth on caregiving time for sons and daughters. Notes: Event–study coefficients relative to $\kappa = -1$; vertical bars indicate 95% confidence intervals.

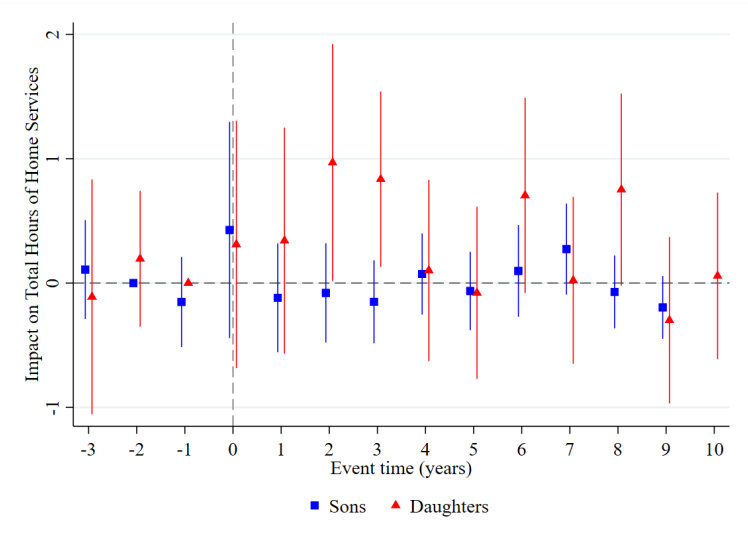


Figure 15: Impact of childbirth on time spent in home services and unpaid domestic work for sons and daughters.

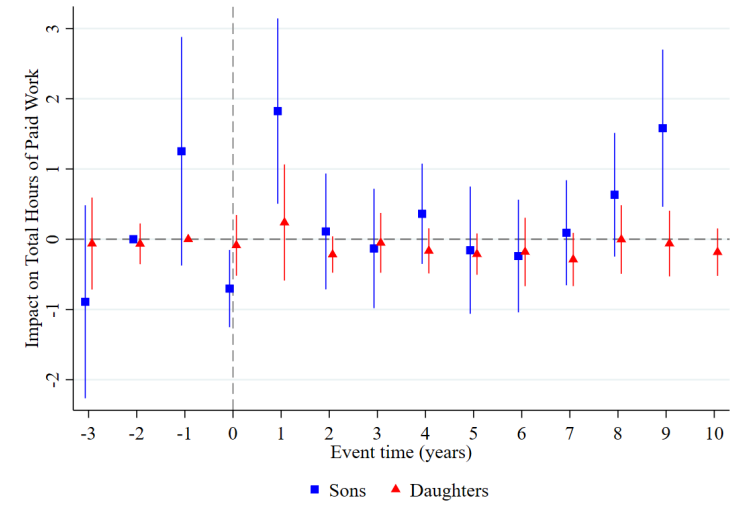


Figure 16: Impact of childbirth on paid work for sons and daughters.

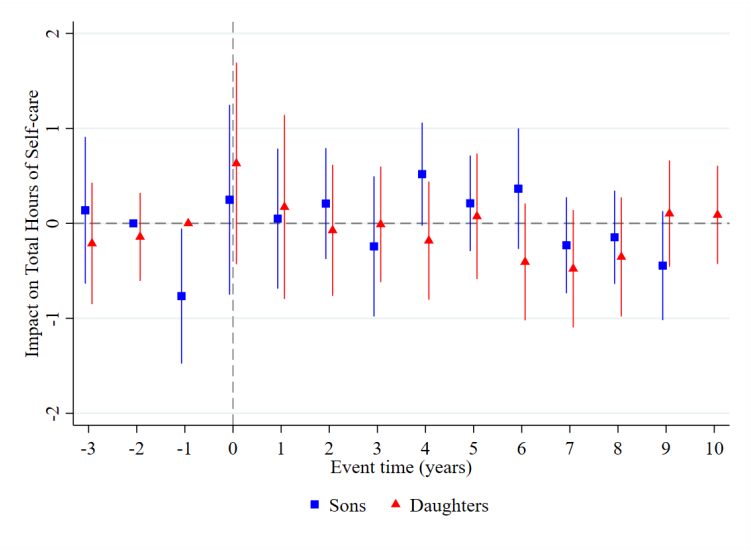


Figure 17: Impact of childbirth on self–care time for sons and daughters.

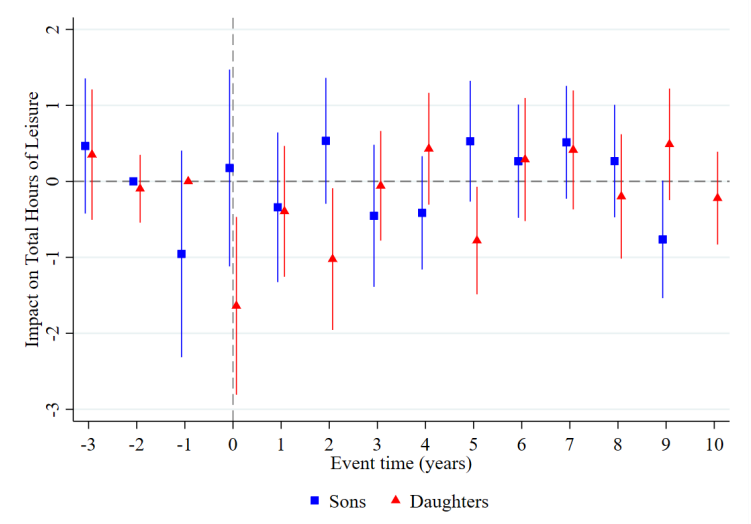


Figure 18: Impact of childbirth on leisure time for sons and daughters.

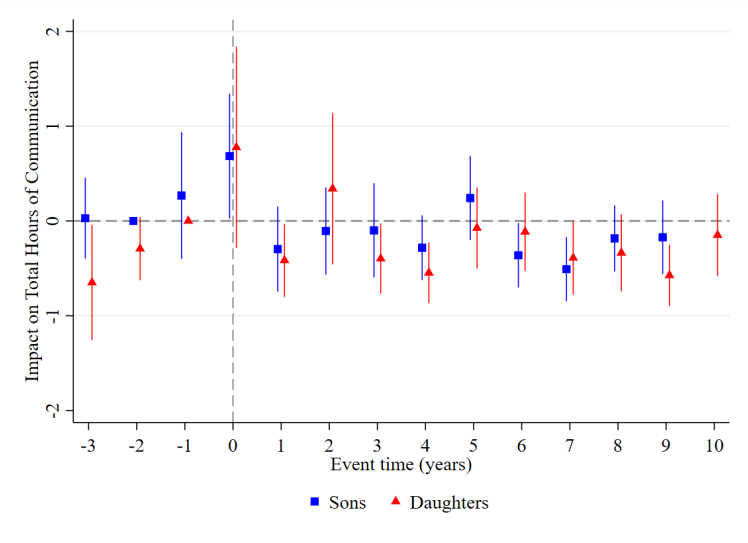


Figure 19: Impact of childbirth on time spent in communication and social interactions for sons and daughters.

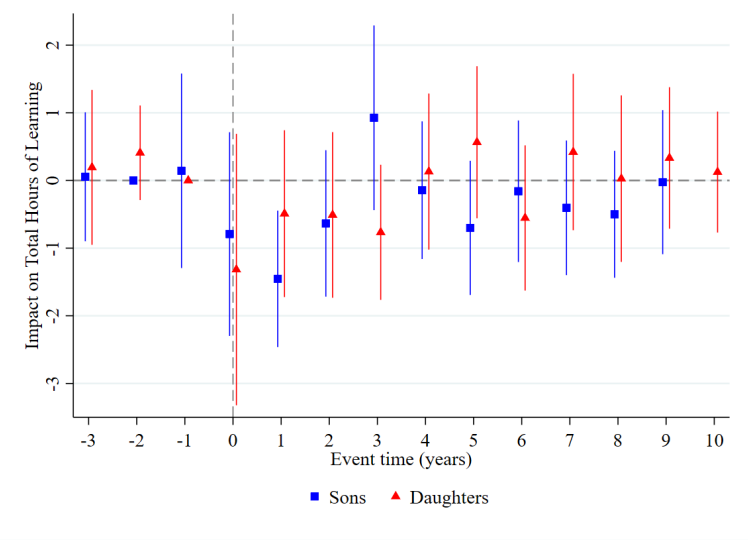


Figure 20: Impact of childbirth on time spent in learning and education for sons and daughters.

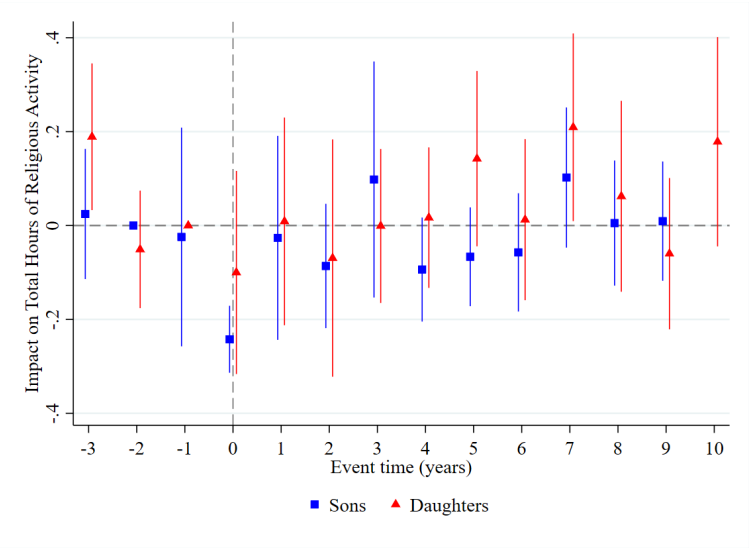


Figure 21: Impact of childbirth on time spent in religious activities for sons and daughters.

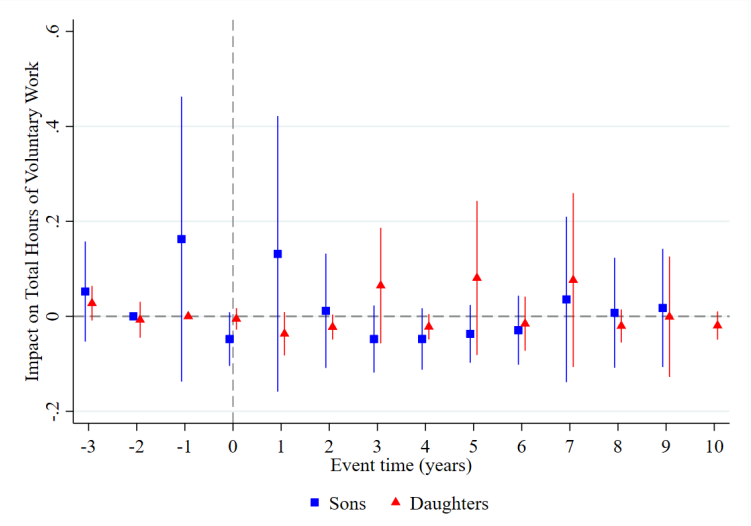


Figure 22: Impact of childbirth on voluntary work for sons and daughters.

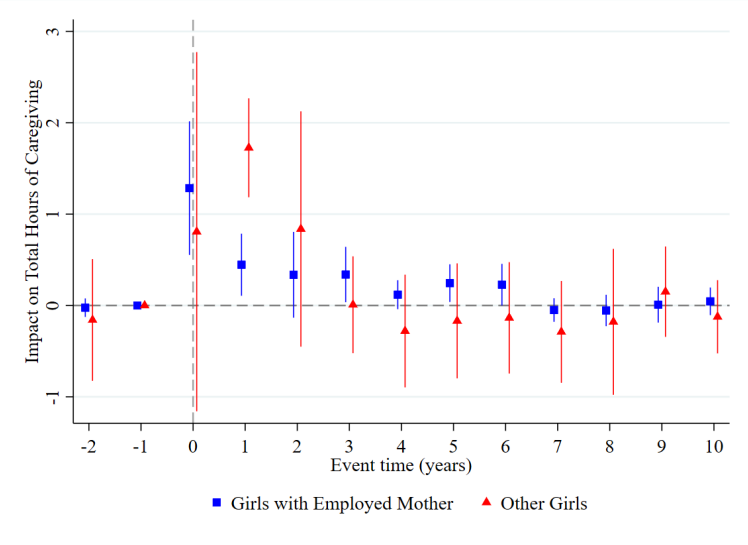


Figure 23: Impact of childbirth on caregiving time for girls, by maternal employment status. Notes: blue squares are girls with an employed mother; red triangles are other girls. Coefficients are relative to $\kappa = -1$; vertical bars denote 95% confidence intervals.

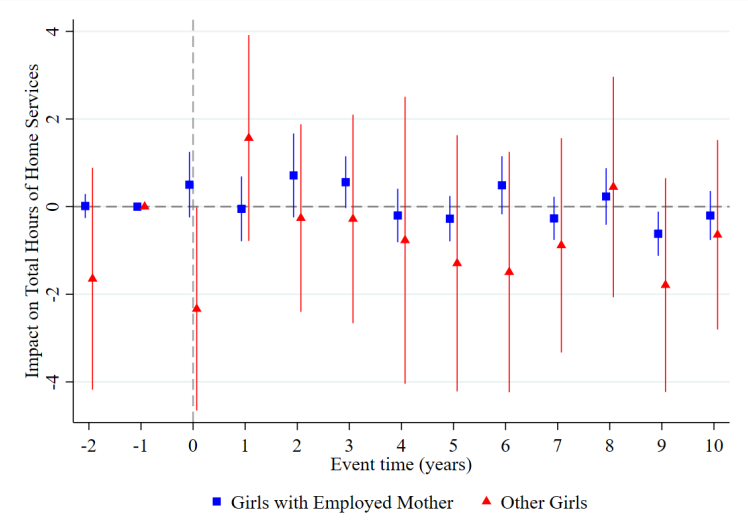


Figure 24: Impact of childbirth on time spent in home services and unpaid domestic work for girls, by maternal employment status.

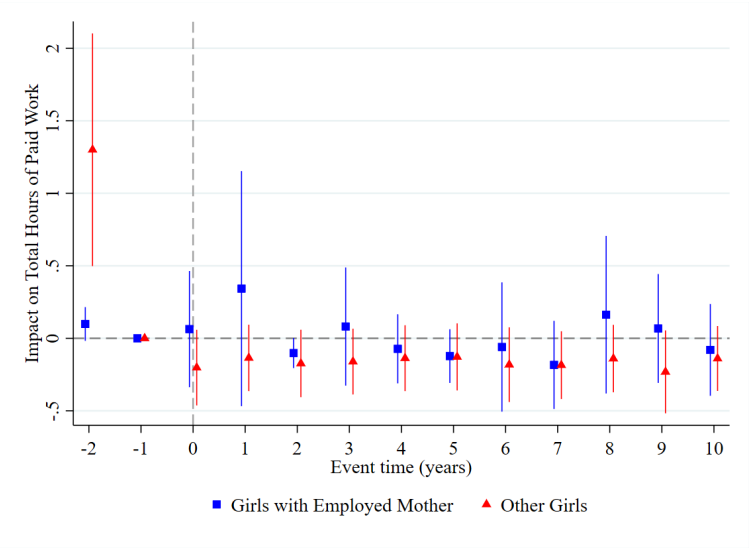


Figure 25: Impact of childbirth on paid work for girls, by maternal employment status.

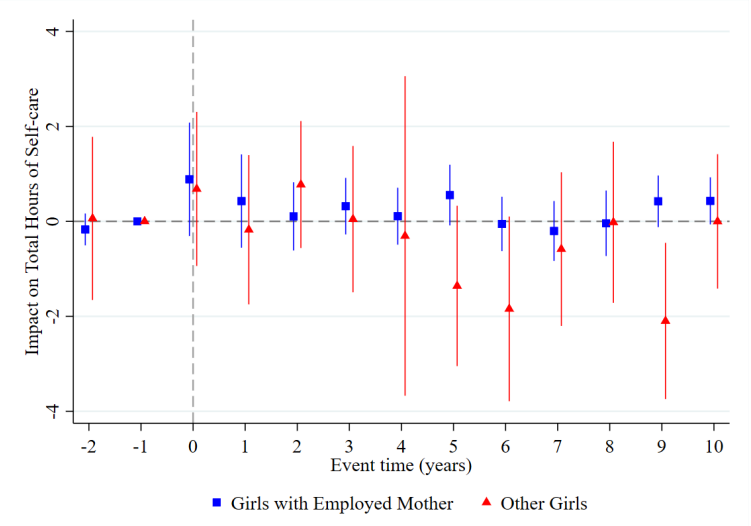


Figure 26: Impact of childbirth on self–care time for girls, by maternal employment status.

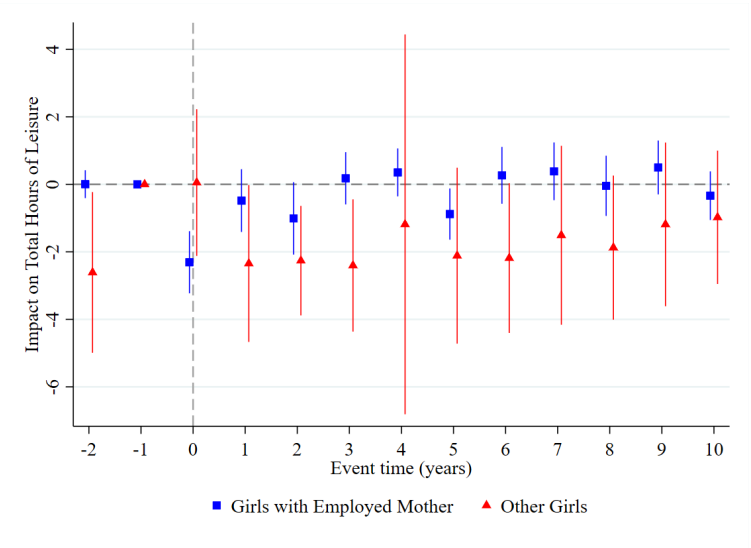


Figure 27: Impact of childbirth on leisure time for girls, by maternal employment status.

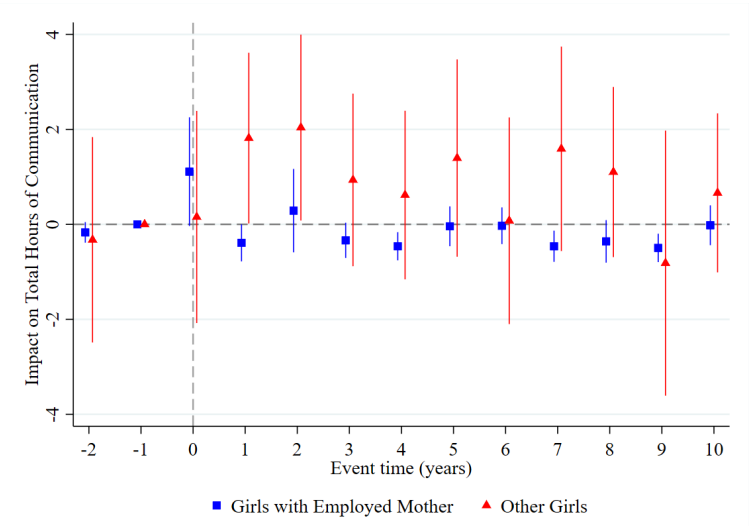


Figure 28: Impact of childbirth on time spent in communication and social interactions for girls, by maternal employment status.

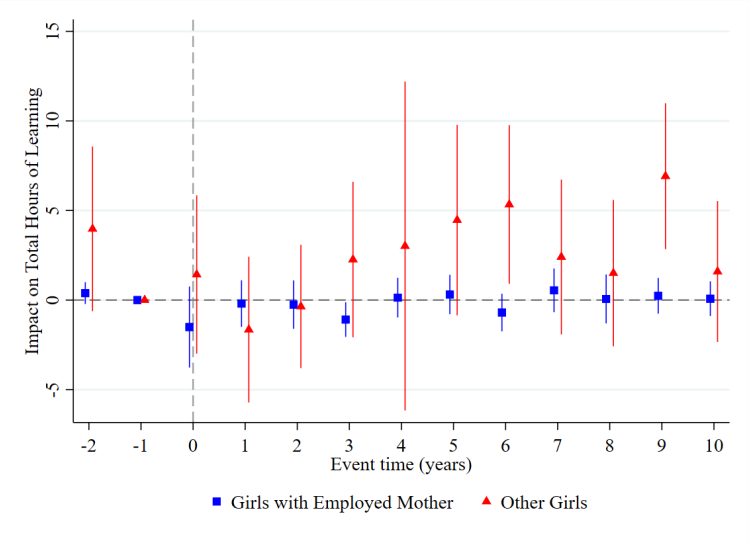


Figure 29: Impact of childbirth on time spent in learning and education for girls, by maternal employment status.

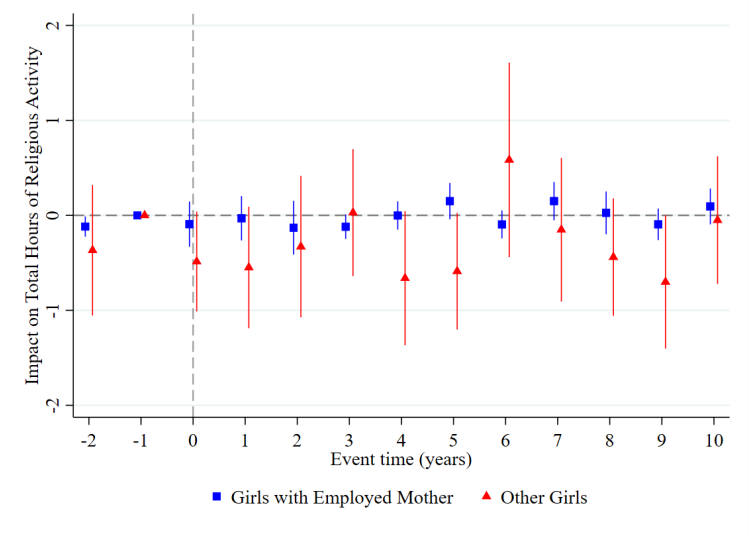


Figure 30: Impact of childbirth on time spent in religious activities for girls, by maternal employment status.

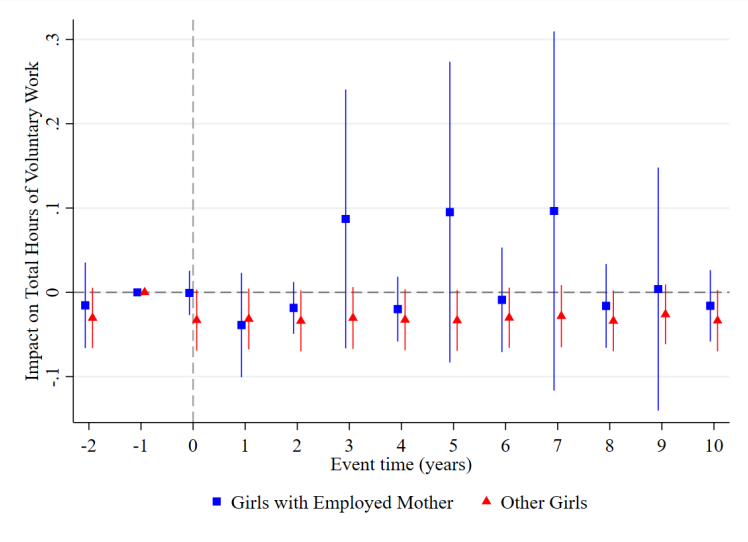


Figure 31: Impact of childbirth on voluntary work for girls, by maternal employment status.