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

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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.

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1 Introduction

Gender inequality in economic outcomes is rooted not only in differences in paid work and earnings but also in how households allocate unpaid time. Across countries, women devote substantially more time than men to home production and caregiving, even when they participate in the labour market (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 disparities reflect both economic constraints and persistent gender norms about appropriate roles inside and outside the home (Alesina, Giuliano, and Nunn 2013; Fernández 2013; Bertrand, Kamenica, and Pan 2015; Bursztyn, González, and Yanagizawa-Drott 2020). Understanding when and how such gendered gaps widen is central to gender economics, because unpaid work is a key mechanism linking family events to labour-market inequality.

A long tradition in economics models household time allocation among market work, home production, and leisure, and studies how this allocation responds to wages, prices, and policies (Becker 1965; Gronau 1977). Within these frameworks, childbirth is a pivotal event: it creates a sudden increase in childcare demand and reshapes who does what inside the family. Recent evidence documents large 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 unequal allocation of unpaid care is widely viewed as a central channel behind these patterns.

These dynamics may be especially salient in middle–income settings with low female labour force participation and strong family roles. In Iran, a large majority of working–age women are out of the labour force, and "personal and family responsibilities" are the dominant stated reason for women's inactivity relative to men (Figure 1). This highlights the central role of unpaid care and domestic work as an often invisible component of gender

inequality in both time use and labour-market outcomes. Yet we know relatively little about how the burden created by childbirth is distributed not only across mothers and fathers but also across other household members.

A growing literature suggests that extended family and older siblings can play an important role in childcare. Grandparents' support may facilitate mothers' employment (Posadas and Vidal-Fernandez 2013; Yamamura and Ohtake 2024), and older siblings — especially sisters — sometimes provide informal care with potential consequences for schooling (Jakiela et al. 2020). However, we lack systematic evidence on whether and how older sons and daughters absorb the additional domestic and caregiving workload generated by a new birth, particularly in contexts where gender norms are strong and formal childcare is limited. If older daughters are treated as flexible, low–cost caregivers, the child penalty may extend beyond mothers and create a previously overlooked "sibling penalty" in girls' time use and human capital investment.

This paper studies how childbirth reshapes intra–household time allocation across parents and older children in Iran, with a 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 — to document patterns of daily time use and estimate dynamic responses to the age of the youngest child. Our empirical strategy adapts the pseudo event–study approach of Kleven (2022) to repeated cross–sections. 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 within a common framework.

The paper makes three contributions to the gender and family economics literature. First, we provide new descriptive evidence on gendered time allocation in Iran. Women devote substantially more time than men to caregiving and home production, while men spend more time in paid work. Comparable, though smaller, gaps are already visible among children: daughters contribute more to domestic work and caregiving and spend somewhat

less time in learning than sons. These stylised facts suggest that gendered specialisation in household production emerges early in life.

Second, we quantify how childbirth reshapes adults' time allocation. 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. These changes are sizable and persistent for mothers, consistent with the broader child–penalty literature.

Third, we document a sibling penalty concentrated among older daughters. Following the arrival of a younger child, daughters increase caregiving and home services more than sons and reduce time spent in learning and leisure by more. While child–level estimates are subject to greater sampling uncertainty than adult estimates, the overall pattern is consistent with the idea that part of the care burden generated by childbirth is shifted onto older girls.

We also explore heterogeneity by maternal employment status. 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 appears somewhat larger in households where the mother is not in paid work, though learning estimates are less precisely measured.

Our findings connect the child–penalty literature on labour-market gender gaps with research on informal care and intergenerational transfers (Posadas and Vidal-Fernandez 2013; Yamamura and Ohtake 2024; Jakiela et al. 2020), dynamic models of household labour supply and home production (Attanasio, Low, and Sánchez-Marcos 2008; Greenwood et al. 2016; Iiboshi, Yoshii, and Ozaki 2024), and work on the 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 Iran, we add evidence from a setting where constraints on formal childcare and traditional gender roles make intra–household adjustments especially informative for understanding the origins of gendered time inequality.

The rest of the paper is organised as follows. Section 2 describes the ITUS, the construction of activity categories, and the sample. Section 3 documents stylised facts on daily time

allocation. Section 3 presents a conceptual framework. Section 5 outlines the pseudo event–study design. Section 6 reports the main results for parents and older children, including heterogeneity by maternal employment. Section 6 concludes.

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 (i) what they were doing (primary activity), (ii) what else they were doing (secondary activity, if any), (iii) where they were, and (iv) 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);

and *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 observe the ages of all co–resident children and define the age of the youngest child, denoted youngest_child_h, as the minimum age among co–resident children. 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, 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, denoted τ_i, defined by the age of the youngest child in the household; thus, τ_i takes

values from 0 to 10, where $\tau_i = 0$ corresponds to the birth year of the youngest child, $\tau_i = 1$ to the next year, and so forth.

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 2 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 3 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 4 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 5 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

$$\frac{\nu_d v'(l_d) + \tau_d}{a_d} < \min\left\{\frac{\nu_m v'(l_m) + \tau_m}{a_m}, \frac{\nu_f v'(l_f) + \tau_f}{a_f}, \frac{\nu_b v'(l_b) + \tau_b}{a_b}, \frac{p_s}{a_s}\right\}, \tag{12}$$

  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 intra–family 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 youngest_child$_h$ as the minimum age among 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 treated adult i, we define the *event time* as $\tau_i \equiv$ 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. 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 given by

$$\text{parity}_i^{\text{pre}} = \text{kid_counter_all}_h - 1. \tag{13}$$

We generate $K = 4$ synthetic pre–event periods $\tau \in \{-4, -3, -2, -1\}$ by mechanically shifting age backward according to

$$A_{i,\tau} = A_i + \tau, \qquad \tau \in \{-4, -3, -2, -1\}, \tag{14}$$

dropping cells where $A_{i,\tau} < 15$.

Each synthetic observation (i, τ) is then matched to all controls j who share age, gender, and pre–birth parity; that is, $A_j = A_{i,\tau}$, $G_j = G_i$, and $\text{parity}_j = \text{parity}_i^{\text{pre}}$, and who by construction have no young children. Let $\mathcal{C}(i, \tau)$ denote the set of matched controls. The synthetic counterfactual outcome is defined as

$$\tilde{Y}_{i\tau} = \frac{1}{|\mathcal{C}(i, \tau)|} \sum_{j \in \mathcal{C}(i,\tau)} Y_j, \tag{15}$$

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 $\tau \in \{-4, \ldots, 10\}$. We define the stacked outcome as

$$Y_{i\tau}^* = \begin{cases} \tilde{Y}_{i\tau}, & \tau < 0, \\ Y_i, & \tau \geq 0. \end{cases} \tag{16}$$

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 $g \in \{\text{men}, \text{women}\}$:

$$Y_{i\tau}^{*,g} = \sum_{\kappa=-4}^{10} \beta_{\kappa}^{g} \mathbf{1}\{\tau = \kappa\} + \phi_{A_i}^{g} + \psi_{\text{year}}^{g} + \varepsilon_{i\tau}^{g}, \tag{17}$$

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 (17) 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

$$\Delta_{\kappa} = \beta_{\kappa}^{\text{women}} - \beta_{\kappa}^{\text{men}}, \tag{18}$$

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 (17), 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 house-

holds 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 6a 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 6b, 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 6c 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 6d 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 6e 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 6f, 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 6h and 6i), 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 6g 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 7a 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 7b). 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 7g 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 7e 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 7d) 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 7f), although the magnitude and precision of the estimates vary across event years. For religious activities and voluntary work (Figures 7h and 7i), 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 7c: 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 8a 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 8b). 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 8e 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 8d and 8f) 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 8g 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 8h, 8i, and 8c), 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.

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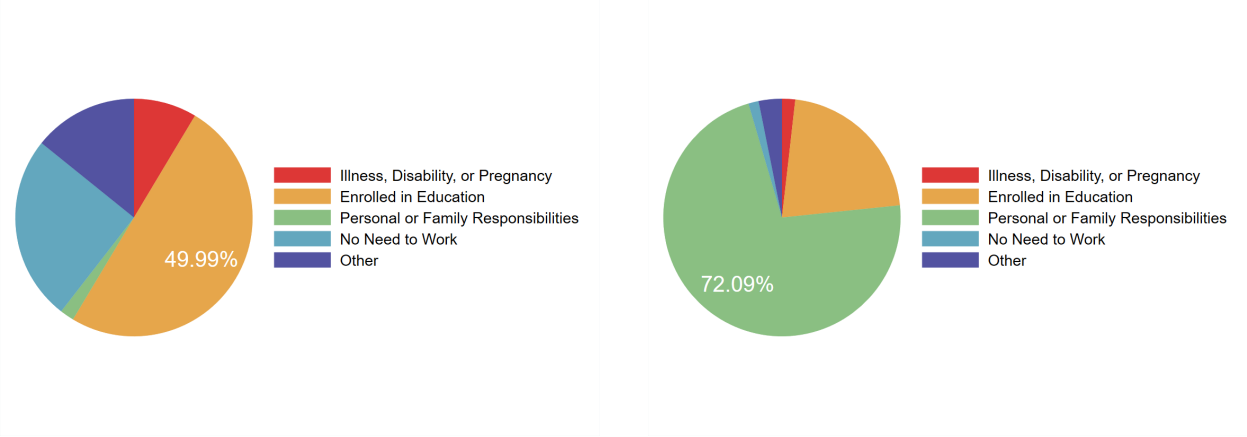
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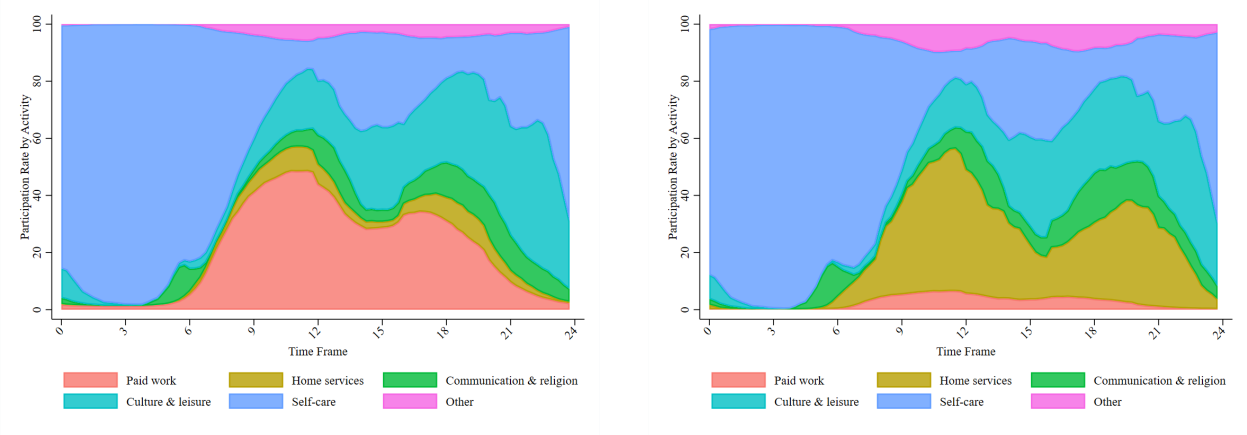
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(a) Men (b) Women

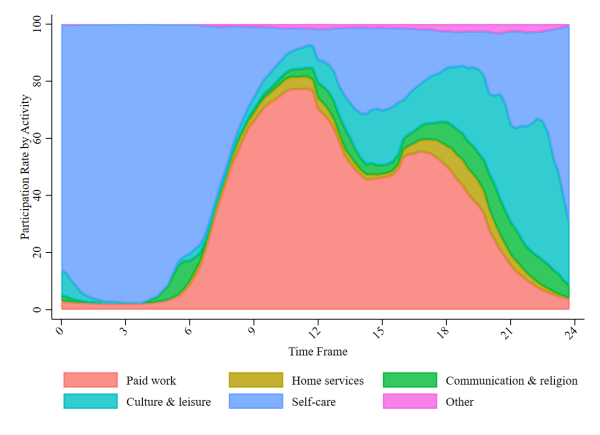
Figure 1: Stated reasons for labour force inactivity by gender. Women are substantially more likely than men to cite "personal and family responsibilities" as the primary reason for not participating in the labour market.



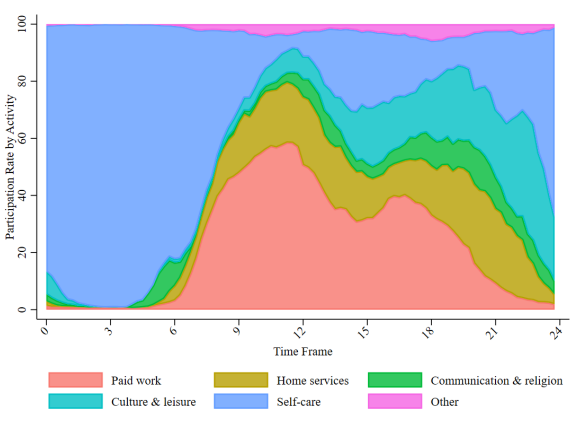
(a) Men

(b) Women

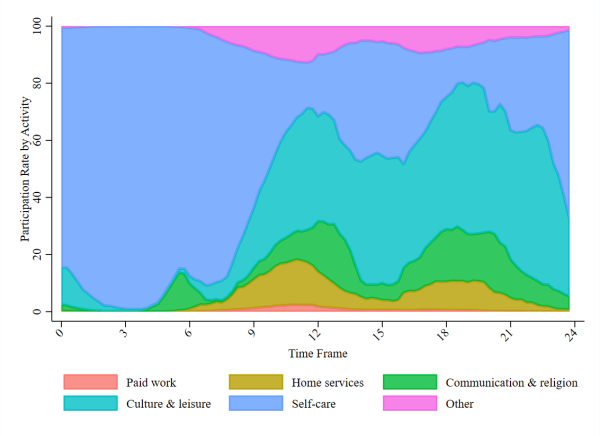
Figure 2: Daily time allocation by gender. Each panel plots the distribution of time across activity categories over the 24–hour day for adult men and women.



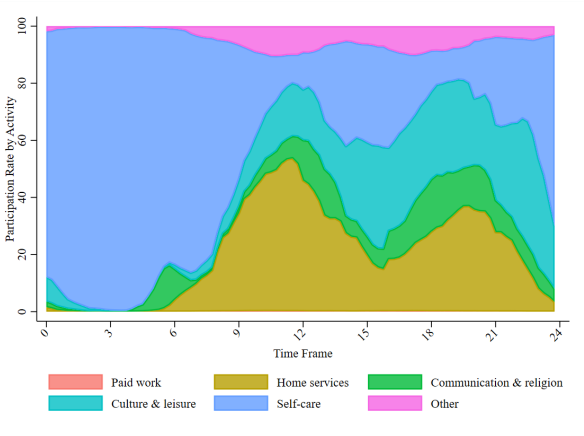
(a) Employed men



(b) Employed women

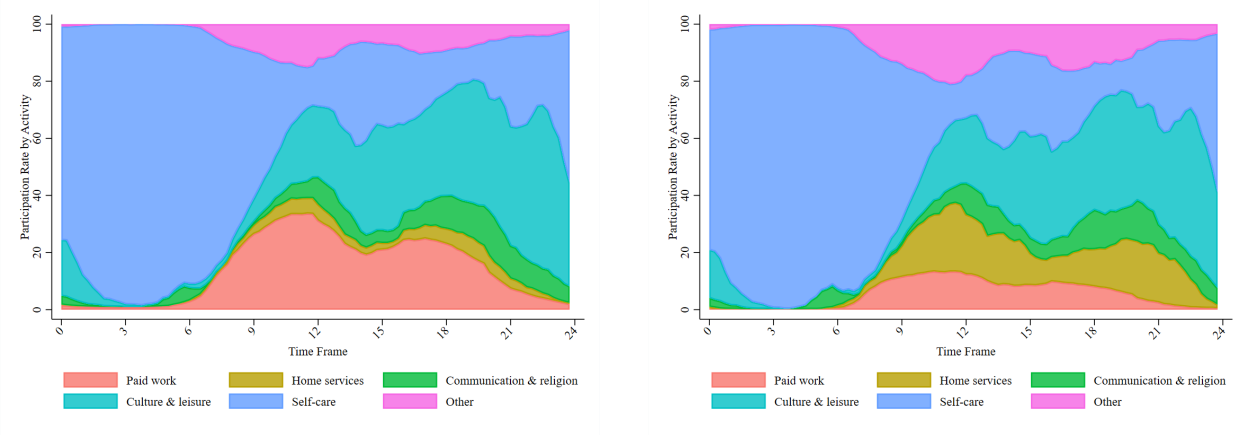


(c) Unemployed men



(d) Unemployed women

Figure 3: 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 4: Daily time allocation for boys and girls. Each panel reports the distribution of time across activity categories over the 24–hour day for children.

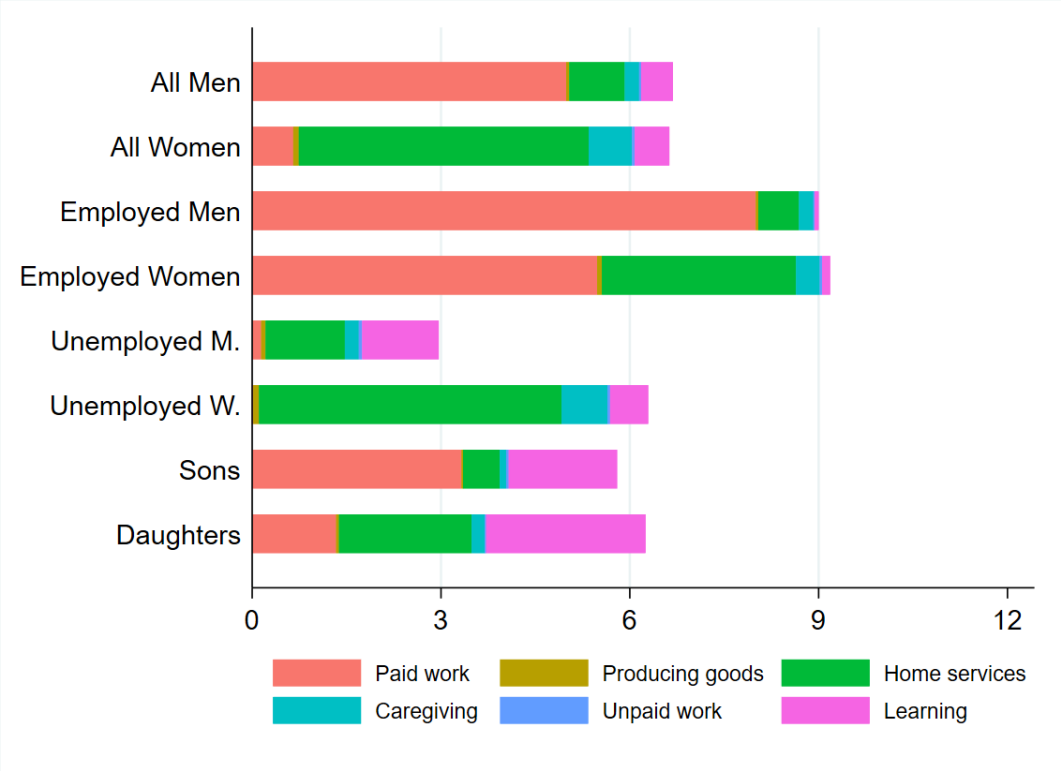
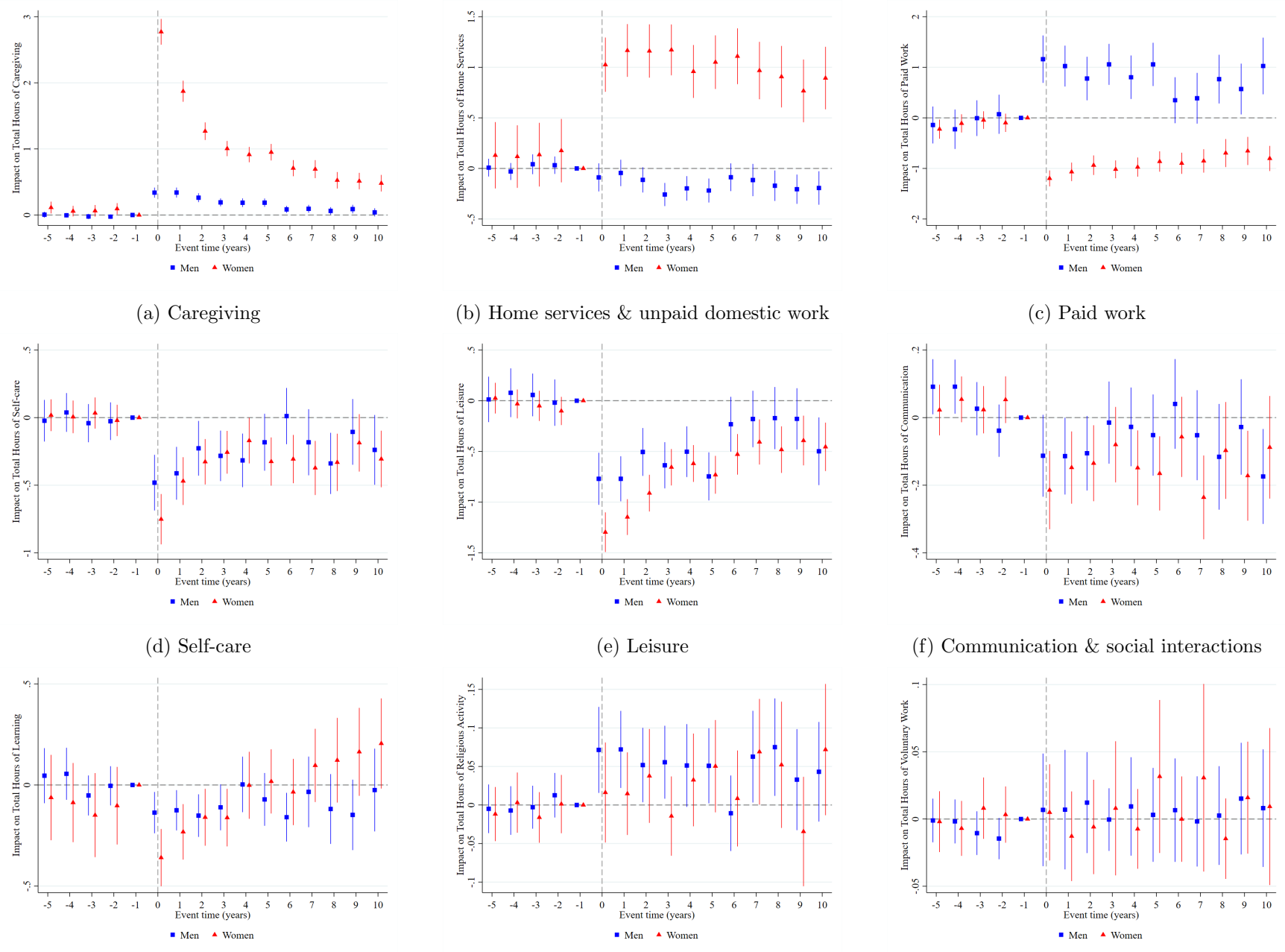


Figure 5: Total minutes per day spent in major activity categories for key demographic groups (all men, all women, employed and unemployed adults by gender, sons, and daughters).

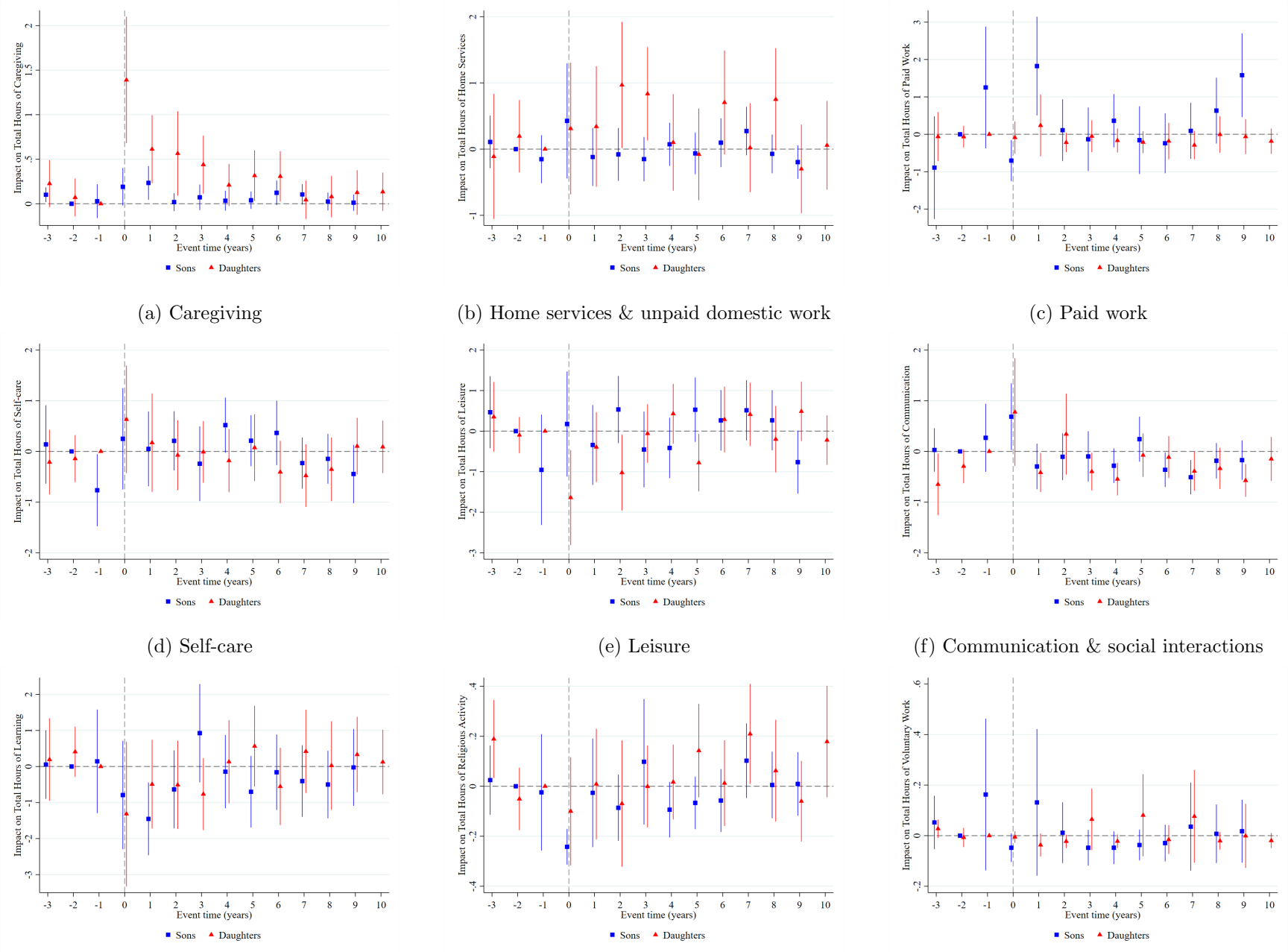


(a) Caregiving (b) Home services & unpaid domestic work (c) Paid work

(d) Self-care (e) Leisure (f) Communication & social interactions

(g) Learning & education (h) Religious activities (i) Voluntary work

Figure 6: Impact of childbirth on time use for men and women across nine activity categories. Notes: Event–study coefficients from equation (17), with $\kappa = -1$ omitted as the reference period. Vertical bars denote 95% confidence intervals.

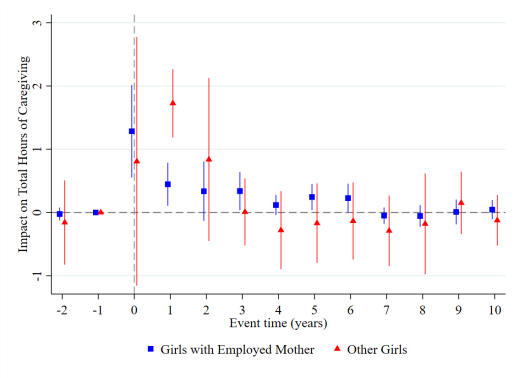


(a) Caregiving (b) Home services & unpaid domestic work (c) Paid work

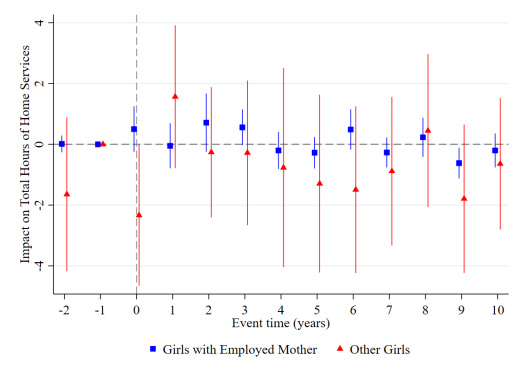
(d) Self-care (e) Leisure (f) Communication & social interactions

(g) Learning & education (h) Religious activities (i) Voluntary work

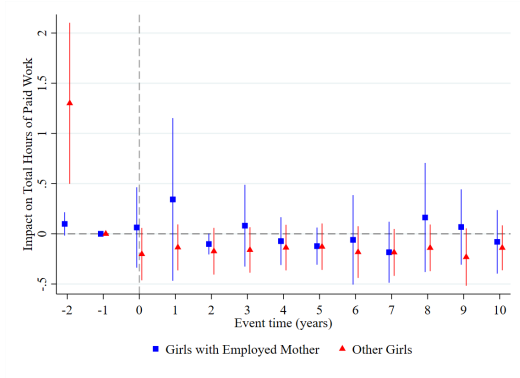
Figure 7: Impact of childbirth on time use for sons and daughters across nine activity categories. Notes: Event–study coefficients relative to $\kappa = -1$; vertical bars indicate 95% confidence intervals.



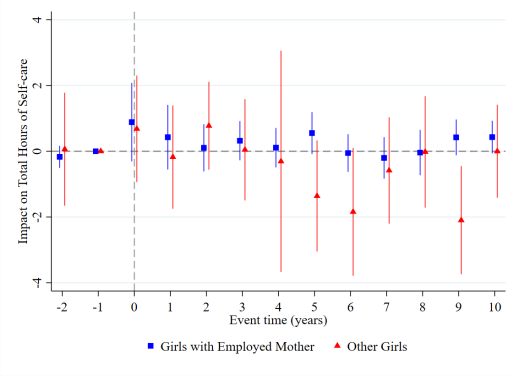
(a) Caregiving



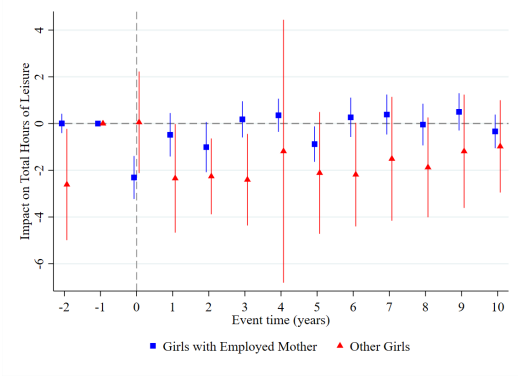
(b) Home services & unpaid domestic work



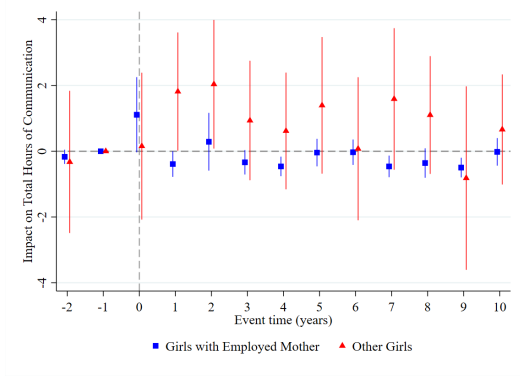
(c) Paid work



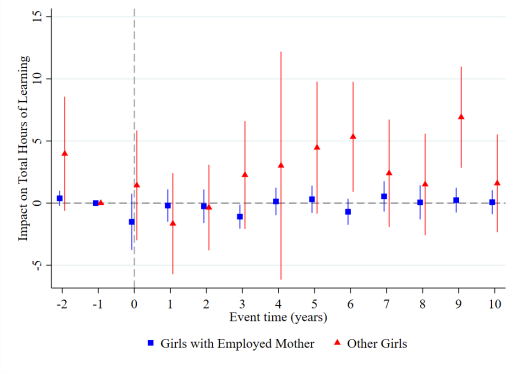
(d) Self-care



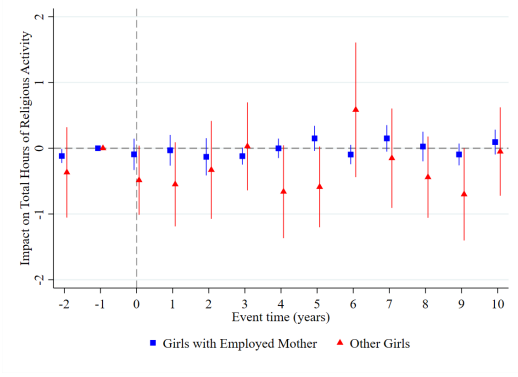
(e) Leisure



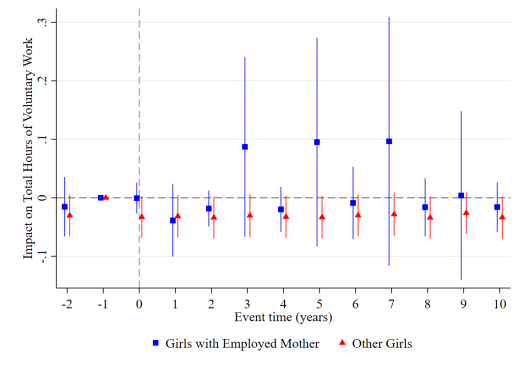
(f) Communication & social interactions



(g) Learning & education



(h) Religious activities



(i) Voluntary work

Figure 8: Impact of childbirth on girls' time use by maternal employment status across nine activity categories. 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.