Gendered Infant Mortality in the Year of the Fire Horse

David Ernst*

Graduate School of Economics, Kyoto University

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Abstract

This study explores the enduring impact of social norms on gendered infant mortality, specifically focusing on child-specific sex preferences. It examines the effect of the Fire Horse superstition in Japan in 1966, which led to a sharp decline in birth rates due to the belief that women born in that year would bring misfortune to their families. By leveraging this unique historical event, I assess how short-term shifts in child-specific sex preferences influenced gendered infant mortality. Using a newly compiled dataset and an event study design, I find that excess female infant mortality during the Year of the Fire Horse accounted for 1,747 deaths or 16.6% of all female infant deaths in the 1966 birth cohort. Even with a parallel-trends-violation-robust estimator, the magnitude of the effect remains substantial, underscoring the profound consequences of child-specific sex preferences and the role of social norms on gender inequality in general. Further analysis of the data on causes and locations of death reveals that gendered infant neglect, rather than gendered infanticide, was the primary driver, with the effect most pronounced in regions surrounding the Seto Inland Sea.

Keywords: Gender Inequality; Discrimination; Infant Mortality; Fire Horse.

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*Address: Graduate School of Economics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, Kyoto, 606-8501, Japan, e-mail: *davidernst.321@gmail.com*

1 Introduction

Since Amartya Sen's seminal "100 Million Missing Women" statement Sen [14], significant advances in healthcare and societal awareness have been achieved. Yet, disparities in prenatal and early childhood mortality across gender lines persist, underscoring the enduring influence of deeply rooted social and cultural norms. These inequalities represent a fundamental challenge to gender equality and development, driven primarily by two key factors: sex-selective abortion and gendered infant mortality.

While the effects of social norms on sex-selective abortion are well-documented, particularly in the contexts of India and China, the drivers of gendered infant mortality remain less understood. The multidimensional nature of gendered infant mortality—encompassing individual behaviors, cultural expectations, and medical developments—makes disentangling the effects of social norms particularly challenging.

One of the main obstacles to understanding the relationship between gender norms and gendered infant mortality is the difficulty of identifying short-term changes in these norms within a causal framework. Social norms are often deeply entrenched and slow to evolve, limiting opportunities for causal identification. I propose to measure the impact of child-specific sex preferences on gendered infant mortality by leveraging a temporal shift in social norms stemming from the Fire Horse superstition in Japan in 1966. According to this superstition, women born in the Year of the Fire Horse are believed to bring misfortune and discord to their families. This belief led to a sharp decline in birth rates, from 2.1 children per woman in 1965 to 1.6 in 1966, as families chose to delay or avoid childbirth altogether.

In this study, I leverage this unique context to measure the impact of short-term changes in child-specific sex preferences on gendered infant mortality. Using a novel dataset and an event study design, I find that excess female infant mortality during the Year of the Fire Horse accounted for 1,747 deaths, representing 16.58% of all female infant deaths in the 1966 birth cohort. Even when employing a parallel-trends-violation-robust estimator, the magnitude of the effect remains substantial, highlighting the profound consequences of

child-specific sex preferences on gendered infant mortality.

By analyzing data on the reasons for death and the places of death, this study demonstrates that neglect—rather than deliberate gendered infanticide—accounts for the observed gendered infant mortality effect. While the effect is observed nationwide, affecting both rural and urban areas, it is particularly pronounced in regions surrounding the Seto Inland Sea, where excess female infant mortality accounts for up to half of all female infant deaths in the cohort in the most severely affected prefectures.

These findings underscore the significant influence of social norms on gendered infant mortality and emphasize the necessity of incorporating social norms into policy frameworks aimed at addressing gendered disparities.

2 Background and Literature

2.1 Background

The "Year of the Fire Horse" (hinoe uma in Japanese) is the 43rd combination in the sexagenary cycle, which pairs 12 zodiac animals with five elements. This specific combination, the Horse and the element Fire, recurs once every 60 years—most recently in 1966, with previous occurrences in 1906, 1846, and the upcoming one in 2026. In Japan, a unique superstition surrounds this year: women born in a Fire Horse year are believed to possess bad personality traits, cause marital discord, and bring misfortune to their families Hashimoto [5] Azumi [3]. Notably, this belief applies exclusively to women; there are no superstitions regarding men born in a Fire Horse year. Though rooted in the broader Chinese zodiac system, Japan adopts the Western calendar, with the year beginning on January 1st and ending on December 31st, rather than aligning with the lunar calendar. While the Chinese zodiac calendar and its associated beliefs are widespread across East and Southeast Asia, the superstition specific to Fire Horse women is a uniquely Japanese phenomenon.

2.2 Literature

This paper contributes to the literature on the effects of child-specific sex preferences, particularly son preferences over daughters, on gendered infant mortality. The impact of such preferences can manifest through both direct and indirect mechanisms. Directly, disproportionately high female infant mortality rates may result from abandonment or violence. Indirectly, neglect plays a significant role, with female infants receiving fewer resources, such as less frequent medical visits, cheaper or no medication, and reduced breastfeeding Jayachandran and Kuziemko [6].

A key challenge in studying the effects of child-specific sex preferences on gendered infant mortality within a causal framework is the persistent nature of these preferences. While changes in social norms can shift these preferences over the long run Jensen and Oster [7], short-term changes in such norms are scarce. Most existing literature on short-term variations in gendered infant mortality attributes these changes to economic conditions rather than shifts in social norms themselves Almond et al. [1] Qian [8].

In this context, the Year of the Fire Horse provides a unique opportunity, offering a short-term disruption in child-specific sex preferences in 1966 that reverted to typical patterns in 1967. To my knowledge, this is the first study to explore the causal effects of a temporary shift in social norms on child-specific sex preferences and gendered infant mortality. Concerning the broader literature on son preference and its relationship to sex-selective abortion, although abortion was legally available in Japan in 1966, the absence of pre-birth sex detection at the time precluded gendered abortion effects during the Year of the Fire Horse. However, this phenomenon may reemerge as a significant topic in 2026, with the advent of modern prenatal technologies.

Furthermore, this research contributes to studies on the socioeconomic and cultural impacts of superstitions, particularly those surrounding the Fire Horse year. Yamada [13] examined the long-term outcomes for women born in Fire Horse years, finding no adverse effects on the labor market or marriage prospects. Other studies, including Rohlfs et al.

[12], have documented the historical effects of various Fire Horse years on birth rates but have not focused specifically on gendered infant mortality. In fact, Yamada [13] argues that excess female infant mortality was not a concern during the 1966 Fire Horse year.

3 Data

To carry out the empirical analysis to test whether the Fire Horse year impacted gendered infant mortality, I constructed a novel dataset focusing on prenatal, birth, and infant mortality data in 1960s Japan. The core of this dataset is drawn from the Japanese Vital Statistics Yearbook[1], which provides monthly, prefecture-level data for many key variables. As these yearbooks are available only as scanned documents, the relevant data was extracted using a deep learning-based image analysis tool tailored to Japanese yearbook statistics developed by Arimoto [2]. I supplemented this dataset with abortion data sourced from the Maternal Protection Statistical Report (Eugenic Protection Statistical Report[2]) and additional information on medical infrastructure and demographic variables from the Japan Statistical Yearbook[3].

Figure 6 shows key birth indicator developments in 1960s Japan. The main takeaways in this regard are: a major birth drop in 1966 with a full back-to-trend recovery in 1967. A countrywide drop in births with no strong regional tendencies. No major change concerning the trend of the absolute number of abortions consequential a major increase in the abortion to birth ratio in 1966 and lastly a major increase in the rate of first-born child ratio in 1966. The figure also highlights changes in the male-to-female birth ratio during the transitions from 1965 to 1966 and from 1966 to 1967. These shifts suggest deliberate gendered birth date manipulation to avoid the Year of the Fire Horse.

[1] www.mhlw.go.jp/toukei/list/81-1.html
[2] www.mhlw.go.jp/toukei/list/botaihogo.html
[3] https://d-infra.ier.hit-u.ac.jp/English/govstat-database/statistical-yb/index.htmll

3.1 Infant mortality

Infant mortality is defined as the death of a child under one year of age. This measure inherently mixes year effects, as infant deaths in any given year partly include those of children born in the preceding year. This is especially relevant when considering ifant mortality rates and addressed through various adjustments in the analysis. Figure 7 illustrates the trends in infant mortality by gender. Both absolute and relative infant mortality rates (infant deaths per births) exhibit a declining trend over the observation period, with male infant mortality consistently higher than female mortality in both measures. However, during the Year of the Fire Horse, a distinct pattern emerges: absolute infant mortality declines for both genders, while relative infant mortality increases. The monthly breakdown of infant mortality by gender further highlights the seasonality of infant deaths during this period. Additionally, the trend in neonatal deaths—those occurring within the first four weeks of life—demonstrates that early infant deaths are a significant driver of the overall infant mortality trend.

4 Empirical strategy

The main empirical approach is to estimate the effect of the social norm shift caused by the Fire Horse year on gendered infant mortality by the following linear panel model with dynamic treatment effects:

$$Y_{igt} = \sum_{s=1963}^{1968} \beta_s \times 1[t = s] \times D_{ig} + \phi_i + \rho_g + \lambda_t + \epsilon_{igt}, \tag{1}$$

where Y_{igt} is the number of infant deaths for prefecture i and gender g in year t; D_{ig} is an indicator for gender (female = 1) in prefecture i; and ϕ_i, ρ_g, and λ_t are prefecture, gender, and year fixed effects. The coefficient β_{1965} is normalized to 0; standard errors are clustered at the prefecture level. As discussed in the previous chapter, infant mortality is defined as death below one year of age. Thus, the Fire Horse infant mortality effect will be captured both in β_{1966} and in β_{1967}.

5 Estimation results

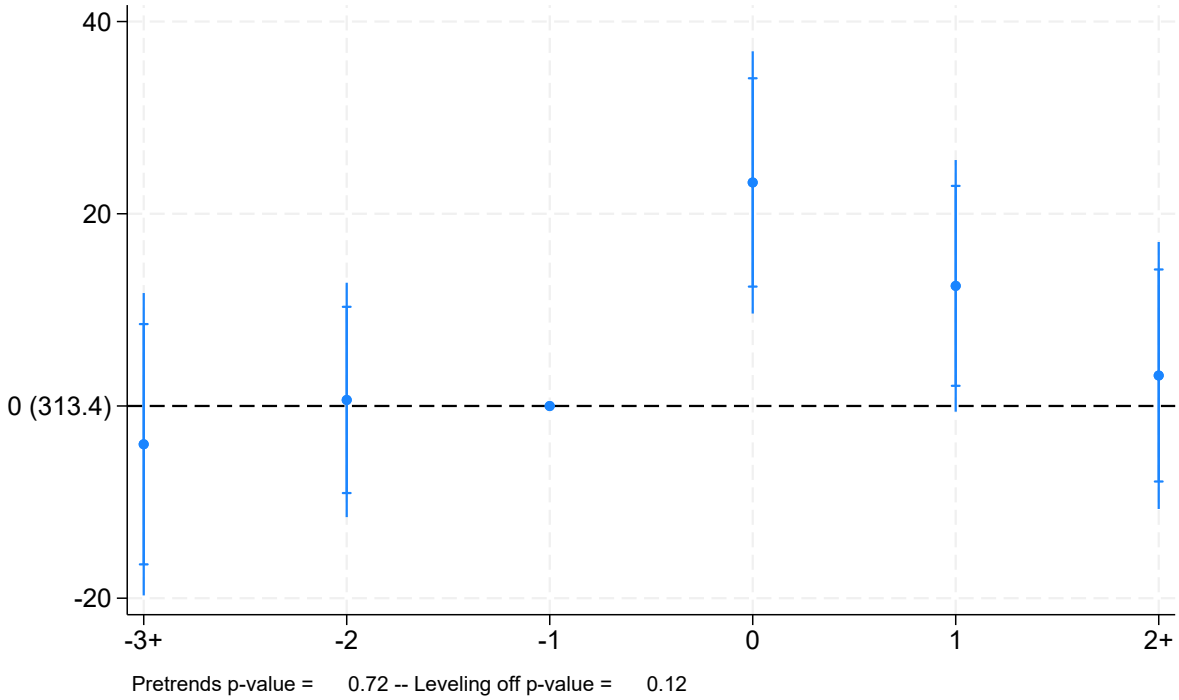
5.1 Main results

Plotting the estimates of (1), Figure 1 illustrates how gendered infant mortality evolves around the year of the Fire Horse. The figure illustrates three points. (no significant pre-treatment trend in gendered infant mortality). First, the Fire Horse year 1966 is associated with a relative increase in female infant mortality of around 22 excess female infant deaths per prefecture. Second, 1967 also exhibits an effect of excess female infant mortality, though smaller than in 1966. This is in line with the prediction as by construction of the dataset also infants of the Horse Cohort who died below the age of one but in 1967 are captured by the data. Third, there is no significant evidence of an effect in 1968 when all children of the Fire Horse Cohort are at least one year of age. As for the magnitude of the effects the beta1966 and beta1967 for 46 prefectures (excluding Okinawa) sum to an excess female infant mortality of overall 1,747 for the Fire Horse Cohort. The data allows to recover all male and female infant deaths for children born in 1966. Using this approach the excess female infant mortality associated with the year of the Fire Horse is 16.58% of the overall infant mortality of the cohort.

5.2 Regional variation

Consider estimating a model of the form of equation (1) for each prefecture, Figure 2a plots the estimates and the respective effect in the percentage of overall female infant mortality in 1966. For example, a value of 180 on the x-axis for Tokyo represents 180 excess female infant deaths in 1966. The corresponding y-value of approximately 18% indicates that these 180 excess deaths accounted for around 18% of Tokyo's total female infant mortality that year. Figure 2b displays the point estimates of the gendered infant mortality effect in 1966, expressed as a percentage of the total female infant mortality for that year. For a given prefecture, a value of -10 indicates that excess female infant mortality accounted for 10% of the

Figure 1: Effects on Gendered Infant Mortality

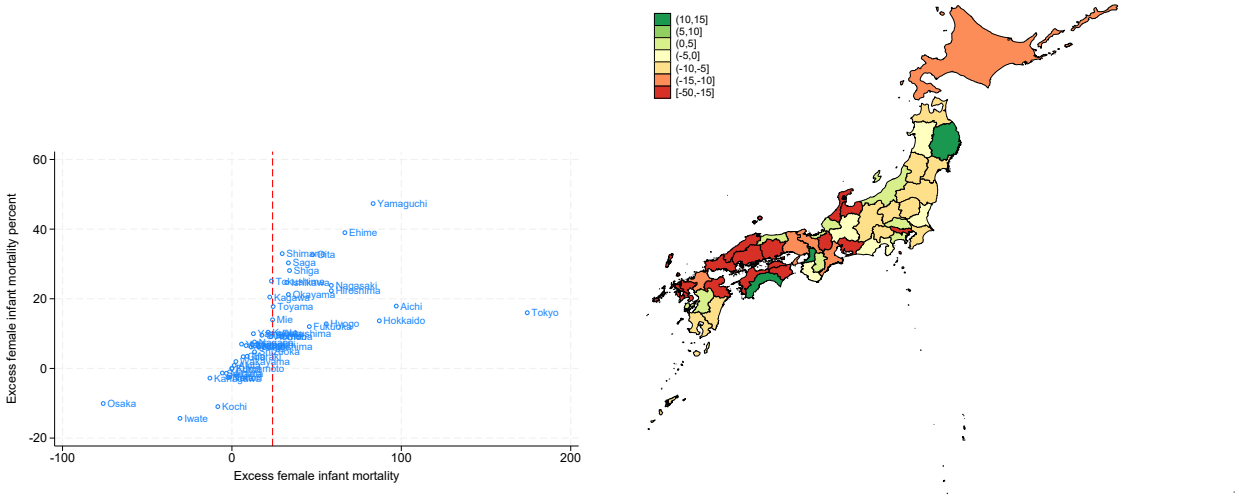


overall female infant mortality in 1966. Conversely, positive values signify excess male infant mortality during the same year. The figures illustrate that while there is no clear regional trend the prefectures around the Seto Inland Sea exhibit higher relative effects. Concerning the two major urban prefectures Tokyo has an above-average excess female infant mortality shock Osaka in contrast exhibits a negative shock, indicating disproportionally more male infant deaths. Further, plotting the estimates of (1) separately for urban and rural populations, Figure 8 illustrates that the effect is evident both in urban and rural areas with smaller absolute effects for rural areas which is, however, in line with the population and number of births differences.

5.3 Driver of excess female infant mortality

Focusing on potential drivers of the effect, as discussed in Chapter 2, there are two potential mechanisms infanticide and neglect. First, as for infanticide, the vital statistical

Figure 2: Effects on Gendered Infant Mortality: Regional Variation



(a) Prefectural Effects on Gendered Infant Mortality

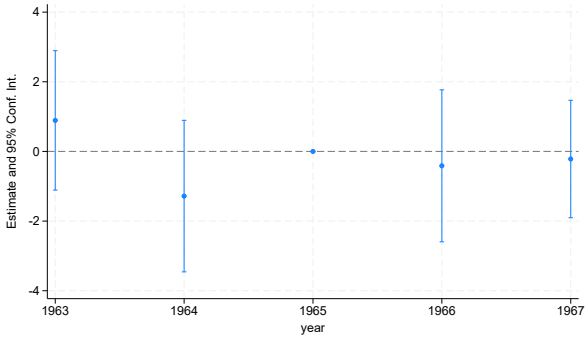
(b) Regional Variation in Gendered Infant Mortality

yearbook contains data on the cause of death of infants. Figure 3a plots the estimates of (1) when restricting the sample to infant deaths that can be associated with active infanticides such as violence and poisoning. The figure illustrates no indication of active gendered infanticide associated with the year of the Fire Horse. Second, as for disproportion neglect of female infants associated with Fire Horse year, the dataset furthermore contains information on the place of death of infant deaths. Here the data allows to separate the infant deaths into two categories, infants who died in a medical institution and infants who died at home or at other place. The hypothesis is that, in case of neglect, parents are less likely to bring their infants to a medical institution if there are potential signs of illness or the like. Unfortunately, while the place of death infant data allows for an urban-rural comparison, the data is not available by gender neither on the prefecture nor on a national level. Thus, the estimates can only be seen as a possible indicator for infant death drivers.

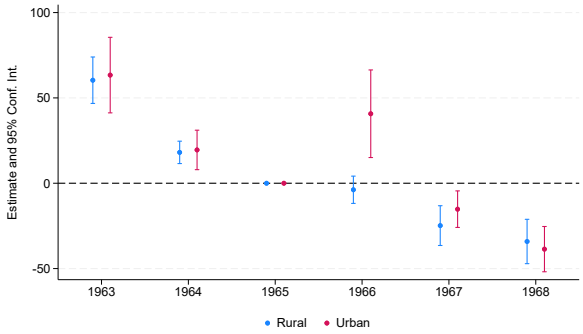
In order to explore the dynamics, I adjust the main model (1) by changing the outcome to $Y_{i,t,p}$, the number of infant deaths in prefecture i in year t, and the place of death p. The new treatment identifier is D_p, which equals 1 for infant deaths at home and 0 for infant deaths in a medical institution. As before the specification includes prefecture and year-fixed

effects and standard errors are clustered at the prefecture level. Plotting the estimates of the place of death specification for all observations and separately for urban and rural areas, Figure 3b illustrates the changes in infant deaths by place of death around the Fire Horse year. The figure highlights two points. First, there is a downward trend for infant death at home relative to infant deaths in a medical institution both in rural and urban areas. Second, only for urban areas, the downward trend is interrupted by an increase in the rate of infant deaths at home in 1966. This indicates that, relative to the trend, a disproportionately higher number of infant deaths occurred at home compared to those in medical institutions in 1966.

Figure 3: Driver of Excess Female Infant Mortality



(a) Effects on Gendered Infanticidal Deaths

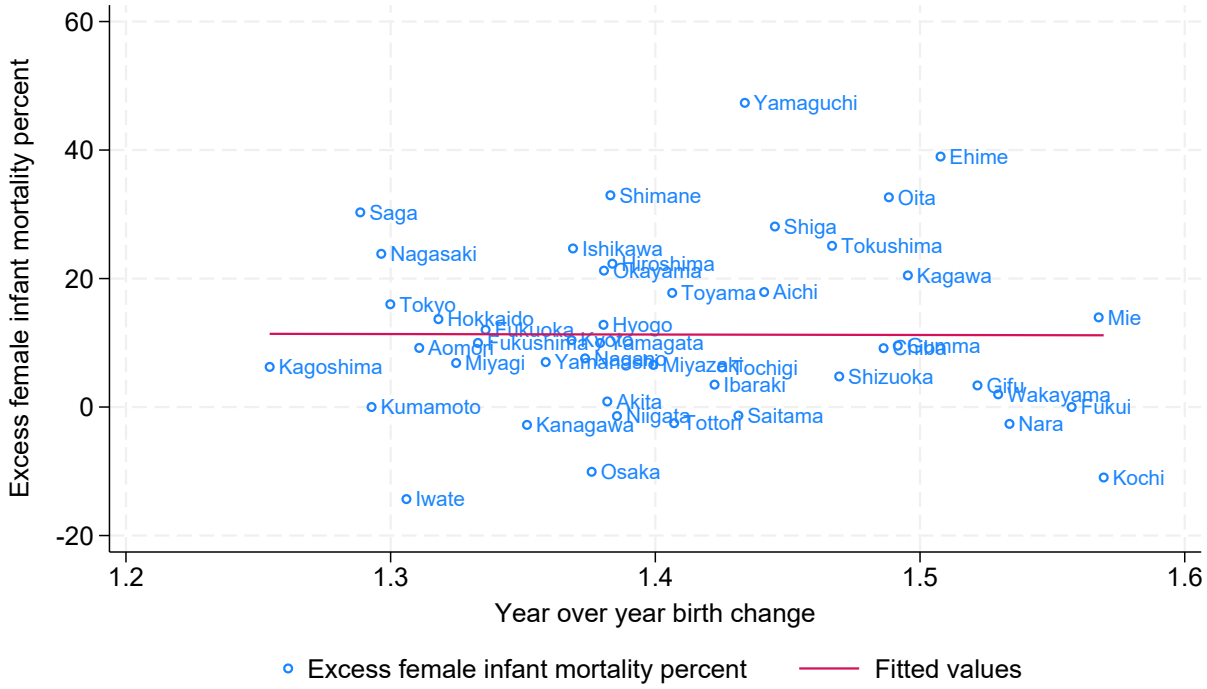


(b) Hospitalization Deaths by Urban and Rural Areas

5.4 Selection effects

While the previous discussion on the drivers of excess female infant mortality around the year of the Fire Horse indicates neglect as the driver, it does not answer the question of the nature of the shift itself. There are two possible explanations. First, the observed gendered effects are caused by the temporal change in sex-selective child preferences as previously discussed. Second, during Fire Horse year there is a higher share of children born in families where female infant mortality is more likely while the change in child-specific sex preferences themselves did not have an influence. Following this reasoning, the excess female infant

Figure 4: Gendered Infant Mortality and Year-over-Year Birth Change in 1966



mortality is a result of selection rather than preference change, caused by the 1966 cohort not being representative of a regular birth cohort.

To address this concern, Figure 4 plots the percentage excess female infant mortality against the year-over-year change of births during the Fire Horse year. If the Fire Horse effect is selection rather than a preference change, a higher year-over-year change in births (birth drop) should be associated with a higher excess female infant mortality. However, Figure 4 illustrates a higher drop in births during the Fire Horse year does not result in a higher gendered infant birth effect, which is a strong argument against the selection hypothesis.

5.5 Confounding effects

Besides the parallel trends violation, the most natural concern of an event study specification is concurrent effects. This would, for instance, concern a temporal disease outbreak that disproportionally affects female infant mortality. I address this concern in two ways.

First, modify the main specification equation (1), changing the outcome from infant deaths to child deaths from 1-2 years of age. Figure 9 shows the event study estimates of the 1-2 year gendered child death specification. The Figure illustrates no gendered effect during the Fire Horse year and a slight positive effect in 1967 which also includes Fire Horse cohort children.

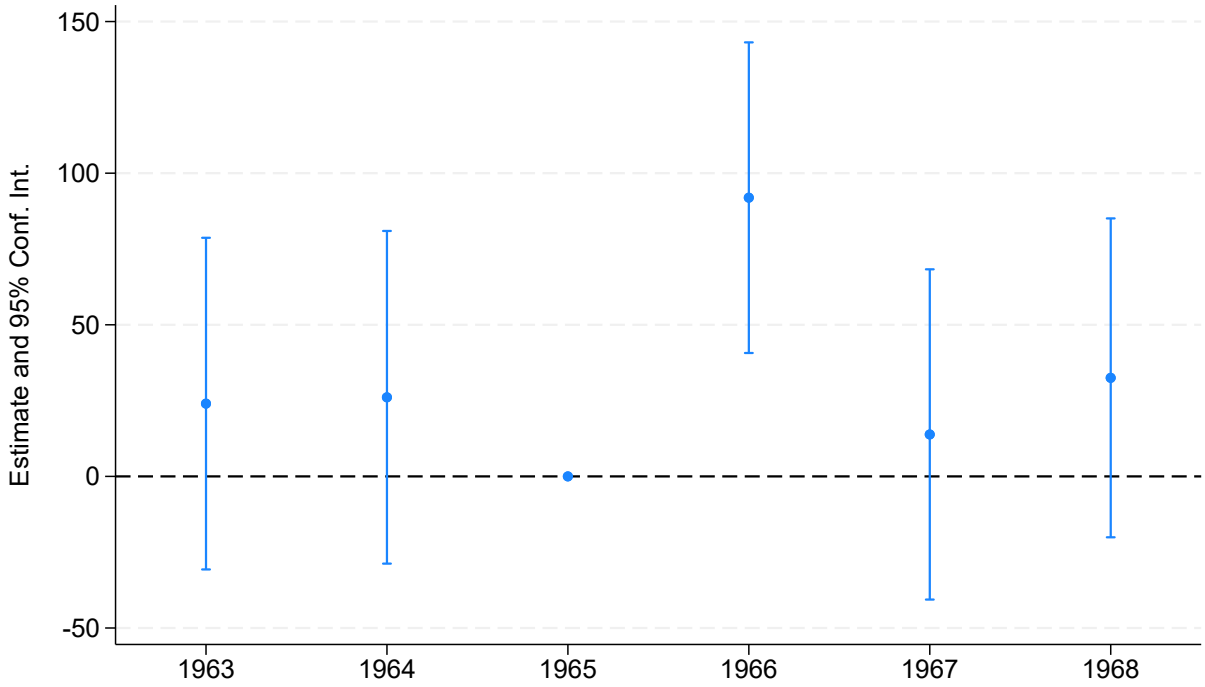
While this is reassuring for the main results, infant mortality occurs predominantly pre-natal period, the first weeks after birth, the approach is still insufficient to cover all concerns of concurrent effects. Therefore the second approach explores a different layer of the data. The vitality statistics dataset contains national-level data on death by year of birth and gender. I utilize this data structure in the following modified event study specification:

$$Y_{gbmt} = \sum_{s=1963}^{1968} \beta_s \times 1[t = s] \times D^1_{gm} \times D^2_{bm} + \cdots + \epsilon_{gbmt}, \tag{2}$$

The new index b indicates whether infant deaths occurred in the year the infants were born. Thus, Y_{gbmt} is the number of infant births for gender g, birth year death indicator b, month m, and year t. Treatment indicator D^1_{gm} is again the gender indicator equal to 1 for female infant deaths in month m; D^2_{bm} is the birth year death indicator equal to 1 for infant deaths that occurred in the year the infants were born and month m. The specifications further include gender, birth year death indicator, year, and their respective interaction fixed effects.

Figure 5 shows the estimates of (2). The estimates illustrate that there is an excess of female infant mortality in 1966 for the infants actually born in the Fire Horse year compared to the infants, born in 1965. In fact, the excess female infant mortality measure in this approach is 1080 for all Japan in 1966 which is close to the results from the main specification, which strengthens the hypothesis of the excess female infant deaths being caused by the Fire Horse effect.

Figure 5: Gendered Birthyear Infant Deaths DDD



6 Robustness

6.1 Rambachan and Roth (2023)

Checking for robust confidence intervals Rambachan and Roth [9], Figure 10 shows, the breakdown value for significant effect is $\overline{M} \approx 1.5$, meaning the effect in 1966 is robust to allowing violation of parallel trends up to 1.5 as big as the max violation in the pre-treatment period.

6.2 Linear Trends Robustness

Moreover, assuming no effect in 1968 as all Fire Horse children are at least one year of age in this year, allows to compare the Fire Horse effect against the linear trend that would lead to the observed effect in 1968. In this case, the trend would be slightly upward-sloping resulting in the estimates of 3.17 in 1968, this would reduce the 1966 Fire Horse effect

itself slightly from 23.26 excess female infant deaths per prefecture (∼1070 national) to 22.17 (∼1019). Furthermore, it allows to define of an upper bound based on the confidence interval enclosed by the 1968 estimates. In that case, the upper confidence bound in 1968 is 14.28 which would reduce the effect of the Fire Horse year to 18.5 (∼851). Thus, assuming no effect in 1968 allows to soften the regular DiD parallel trends assumption to a linear trends assumption. This means the estimates in 1966 is robust against any linear parallel trends violation. Figure 11 visulizes this approach for the different parallel trends violation.

6.3 Freyenhofer et al. 2021

In addition to linear trend violation, Figure 12 shows the least wiggly part that would be needed to ensure no significant effect in the post-treatment period Freyaldenhoven et al. [4]. The wiggly confounding dynamics required to explain the event-time path of the outcome make it implausible that a confound is driving the observed effects. This strengthens the case that the Fire Horse superstition indeed has a causal impact on gendered infant mortality. The results are furthermore robust against, choosing 1964 as the base period, omitting December and January in case of potential manipulation effects, and also excluding major cities.

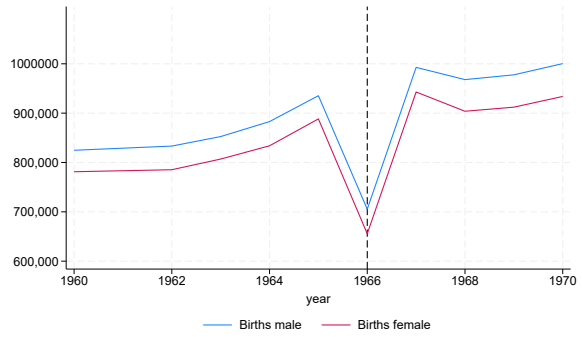
7 Concluding remarks

Social norms continue to be a significant driver of gender inequality, hindering progress toward gender equality in critical ways. This paper demonstrates the profound impact of social norms on gendered infant mortality, using the temporal shift in social attitudes during 1966, when female children were considered less desirable than male children, as a case study. The sharp increase in excess female infant mortality during this period highlights the lasting influence of societal attitudes on gendered outcomes. As social norms reverted, the effect dissipated, emphasizing the importance of addressing these norms in efforts to achieve gender equality.

The findings also reveal that the effect was nationwide, affecting both urban and rural areas, though it was particularly pronounced in regions around the Seto Inland Sea. Future research should explore the underlying reasons for the heightened vulnerability in these areas, investigate the long-term effects on early child development, and examine differences in infant mortality between deaths in hospitals and at home, particularly in urban versus rural contexts.

Appendix

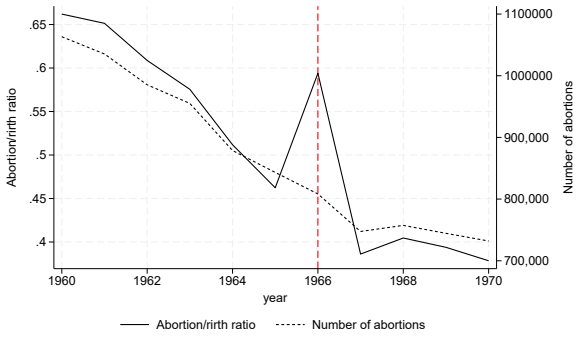
Figure 6: Overview of key birth and abortion indicators in 1960s Japan.



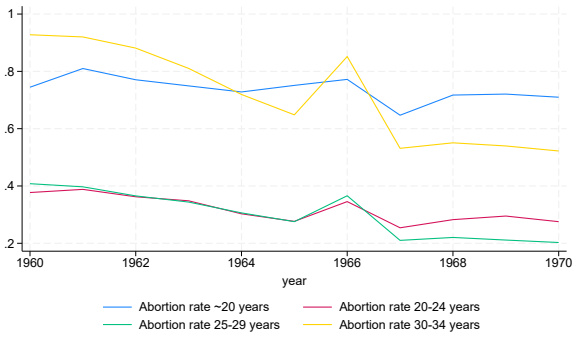
(a) Absolute Number of Births by Gender



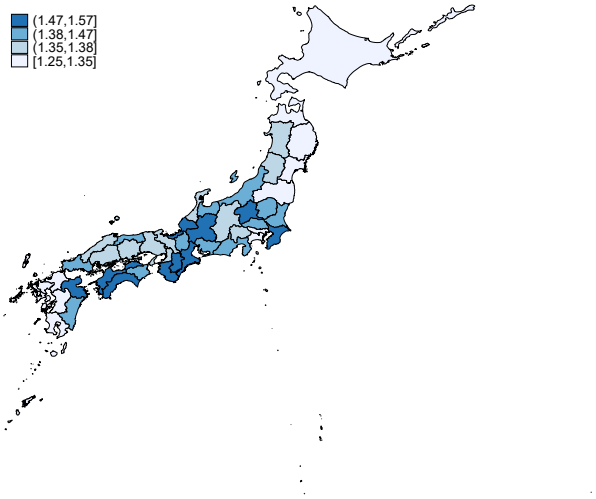
(b) Monthly Births by Gender



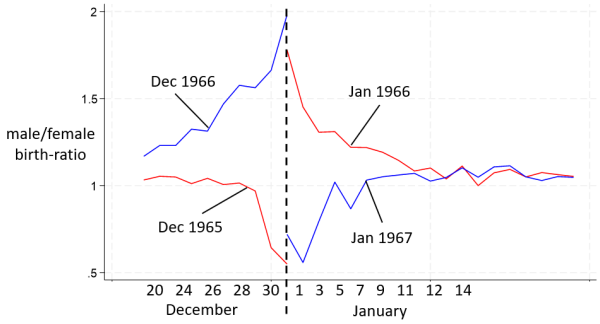
(c) Abortion in 1960s Japan



(d) Abortion by Age Cohort

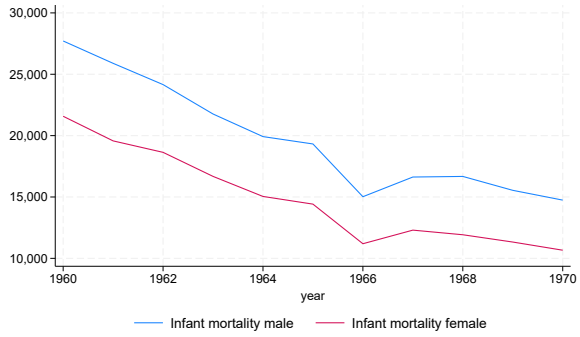


(e) Year-Over-Year Birth Change in 1966

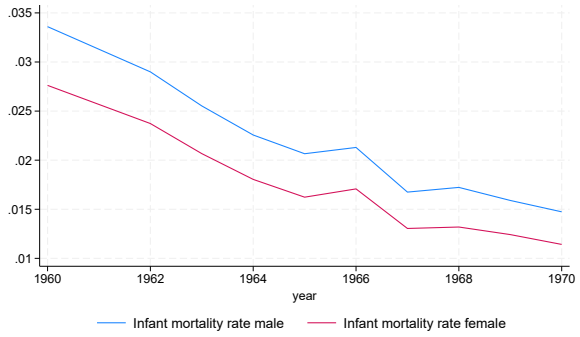


(f) Birthdate Manipulation

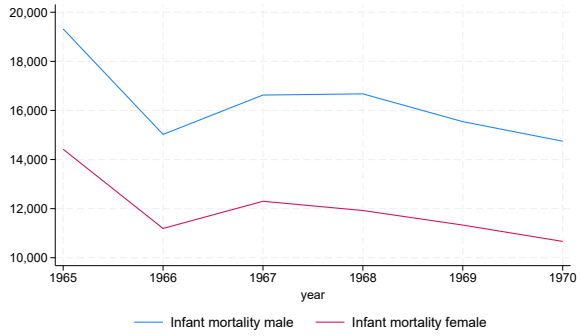
Infant and Neonatal Mortatliy in 1960s Japan



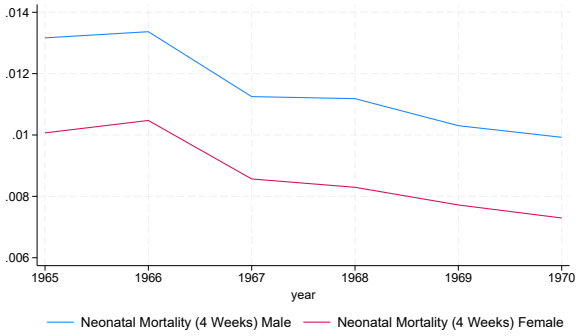
(a) Absolute Number of Infant Births



(b) Infant Birth Rate



(c) Absolute Number of Neonatal Infant Births



(d) Neonatal Infant Birth Rate

Figure 7: Overview of infant and neonatal birth indicators in 1960s Japan.

Figure 8: Effects on Gendered Infant Mortality- Urban and Rural Areas

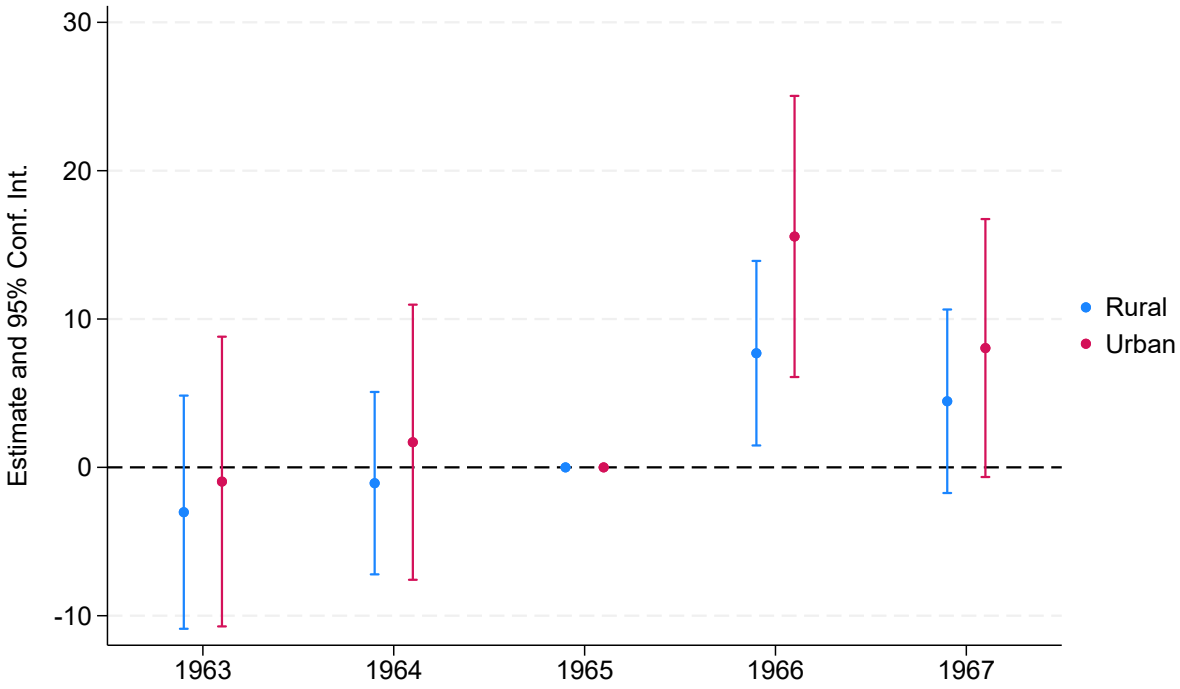


Figure 9: Effects on Gendered Child Mortality 1-2 Years of Age

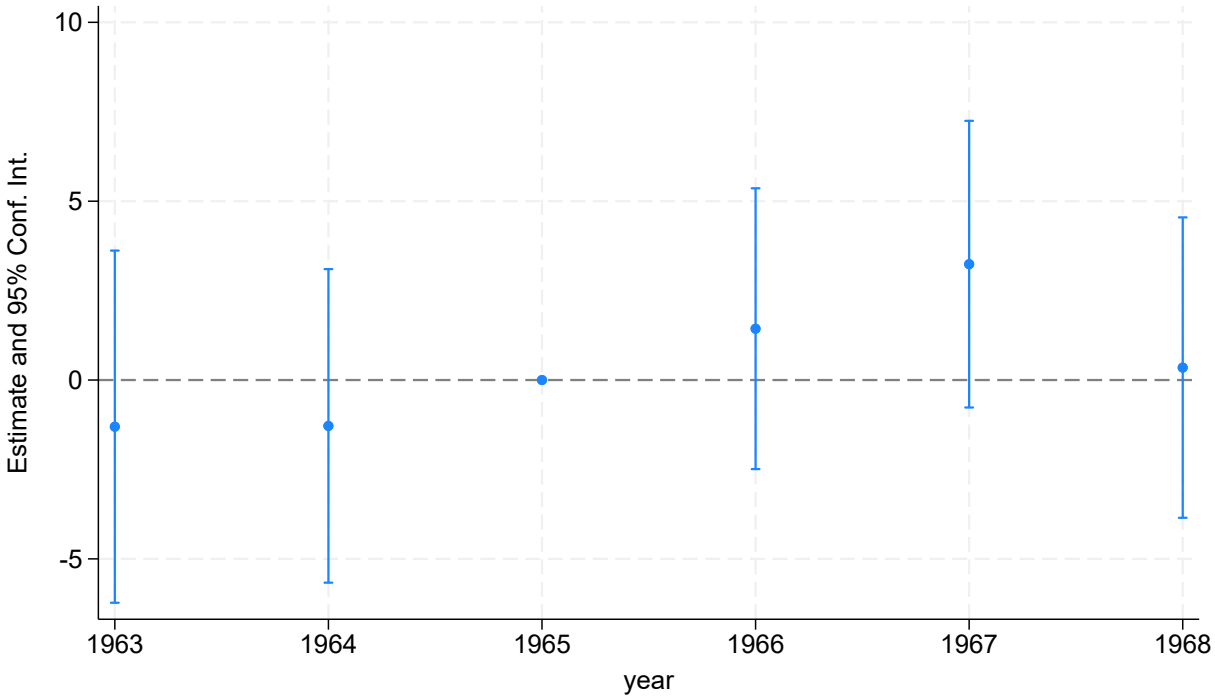


Figure 10: Gendered Infant Mortality in 1966

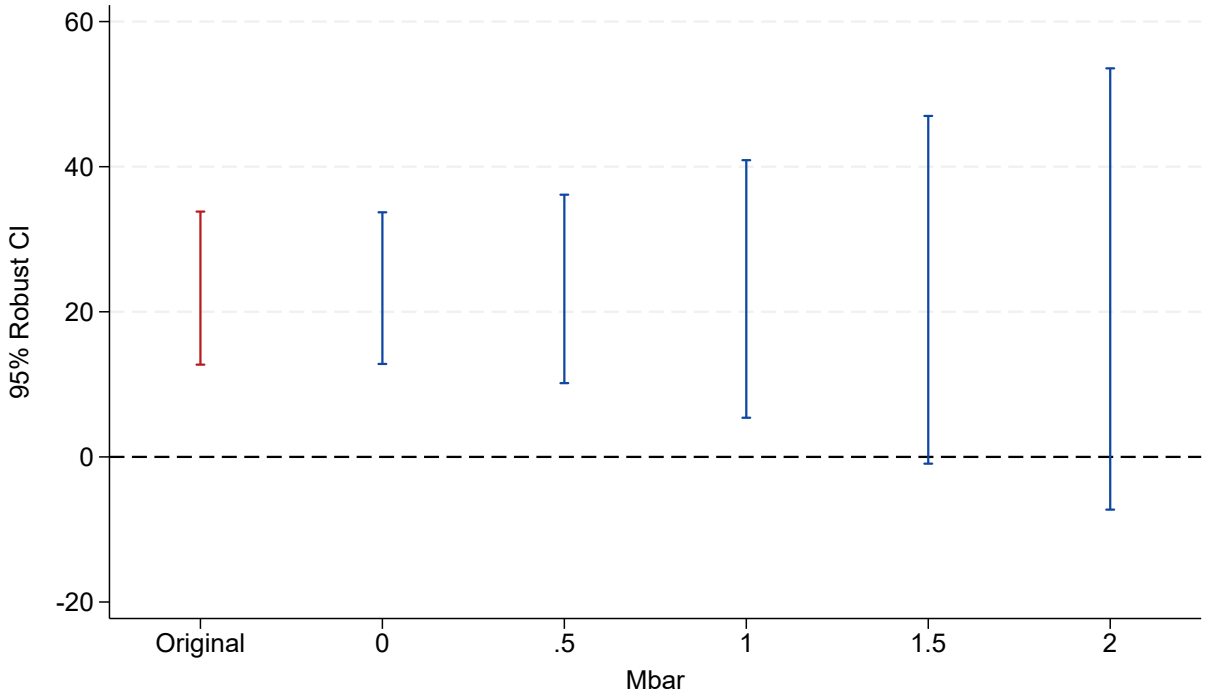
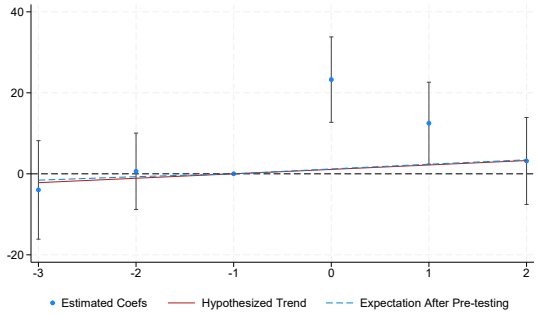
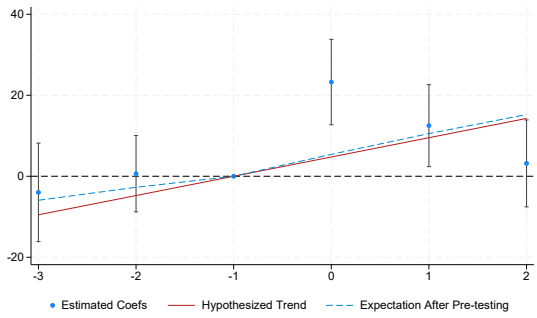


Figure 11: Violations in Parallel Trends

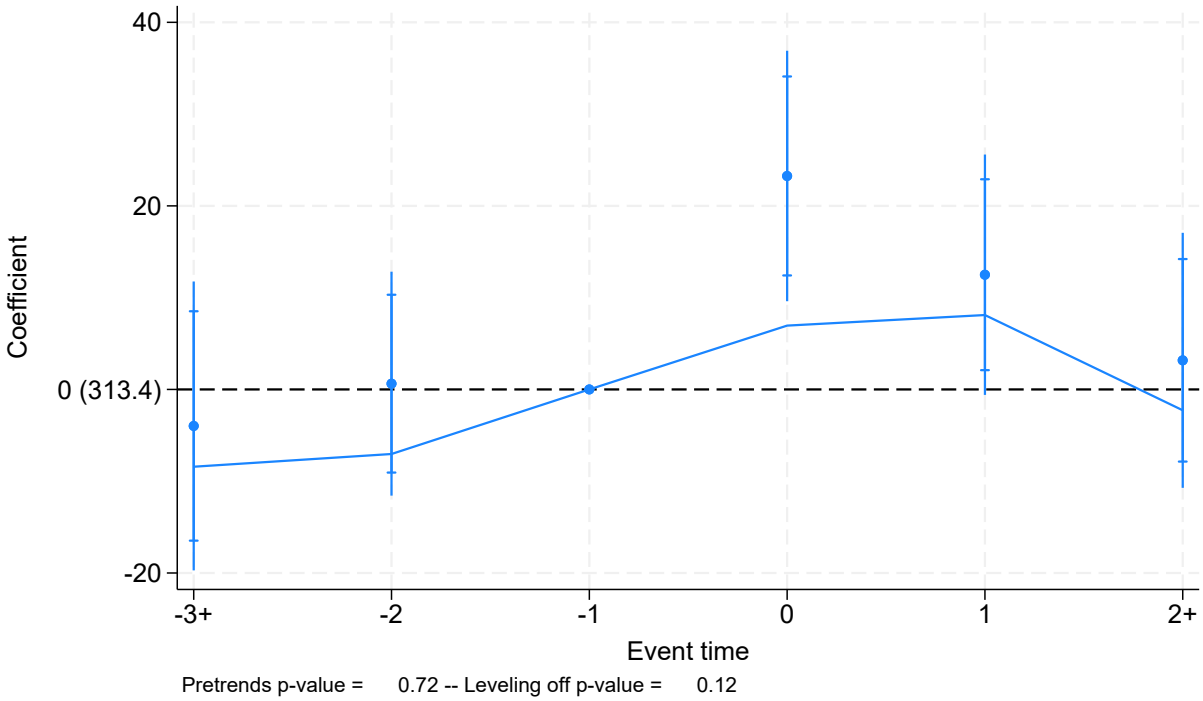


(a) Average Violation in Parallel Trends



(b) Upper Confidence Bound Violation in Parallel Trends

Figure 12: Least "wiggly" Path of Confound



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