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# ABSTRACT

## Consequences of War: Japan's Demographic Transition and the Marriage Market*

This study explores the effects of imbalances in the sex ratio, and their impact on intra-household bargaining, on both the quantity and the quality of children. We first present the theoretical model of intra-household bargaining in the presence of conflicting family goals within a couple, and show that male scarcity (a decrease in the male to female sex ratio) induces an increase in the number of children, but a decrease in the quality of children. Second, using the impact of World War II on the sex ratio, as a quasi-natural experiment, we establish empirically that the decrease in the male to female sex ratio in World War II contributed to a lower decline in fertility and child mortality rates in postwar Japan. In particular, the fertility rate would have fallen by an additional 12% and the child mortality rate by an additional 13% between 1948 and 1970, in the absence of the decrease in the sex ratio.

**JEL Classification:** J11, J12, J13, J16, N15, N35

**Keywords:** quantity–quality trade-off of children, bargaining power, marriage market, sex ratio

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# 1 Introduction

Recent studies suggest that the empowerment of women in the course of human history has contributed to the decline in fertility rates and the increase in child quality.[1] In both developed and developing countries, women tend to favor lower fertility and higher child quality,[2] reflecting the adverse effects of fertility on their labor force participation and the socio-economic conditions. Moreover, evolutionary forces have intensified the degree of altruism of women with respect to each child's quality. Empirical studies confirm that the rise in the bargaining power of women contributed to the consumption, educational achievement, and health status of children (Lundberg et al. 1997; Maitra 2004). Furthermore, the literature also finds that women play a key role in the decline in fertility (Iyigun and Walsh 2007; Rasul 2008; Doepke and Tertilt 2009; Fernandez 2014; Rees and Riezman 2012; Komura 2013; Doepke and Kindermann 2014).

According to the literature on intra-household allocations that occur through Nash bargaining, the determinants of the power balance between men and women include the labor and marriage market environments and legislation systems, which can influence the outside options of current marriages (Chiappori et al. 2002). In particular, in the process of economic development, fundamental systems such as marriage and legislation influence the gender power balance, as demonstrated by several researchers.[3]

In the marriage market, the sex ratio can be a determinant of the power balance within a marriage. Suppose that every individual prefers to be married than to remain single. Under monogamous marriage systems, an imbalance in the sex ratio (i.e., demand and supply) is resolved through price adjustments represented as favorable matching or the intra-household distribution. Theoretically, in a community with a low (high) sex ratio (the ratio of marriageable men to marriageable women), women become unfavorable (favorable) in the marriage market. This is because there are fewer potential partners,

[1]Since the seminal works by Becker, numerous studies have documented the role of the quantity-quality-trade-off with regard to children (see Becker and Lewis 1973; Becker and Barro 1988; Barro and Becker 1989; Becker et al. 1990). The underlying mechanism of Becker's theory, the shift toward quality is led by preference, i.e., the higher elasticity of child quality with respect to income. On the contrary, the unified growth theory, in the vein of Galor and Weil (2000) and Galor and Moav (2002), explains this shift as the change in the relative net returns between child quality and quantity triggered by an event such as the Industrial Revolution, which drastically improves the returns from education. Recent studies using historical events, focusing on the quality–quantity tradeoff of children, support the quality and quantity tradeoff, thereby, favoring the latter explanation (Galor 2012; Fernihough 2017; Shiue 2017; Klemp and Weisdorf 2018). These findings on the interrelation between economic growth and family planning by households suggest that a shift toward quality can benefit the overall economy. Departing from these existing studies, we adopt a non-unitary model to attempt to explain the negative relation between the quantity and quality of children from the perspective of the sex ratio and intra-household bargaining over family planning. For excellent surveys, see Doepke (2015) and Fernihough (2017).

[2]See Testa (2006) and Westoff (2008).

[3]Women's liberation can also alter the power balance within a marriage by affecting the outside options of the current marital relationship (Doepke and Tertilt 2009; Fernandez 2014).

and thus, there is a lower probability of finding a marital partner. Consequently, women need to accept a lower price (i.e., a less favorable marriage).[4]

To bridge the relationship between the marriage market and intra-household bargaining decisions on family planning, we first provide a simple theoretical model that combines two economic theories on the marriage market and intra-household bargaining over the quantity and quality of children. In the model, the couple bargain over the distribution in the presence of conflicting family goals (i.e., the quantity-quality trade-off) following collective models on family planning, such as that of Rees and Riezman (2012). Second, we apply our theory to an empirical analysis to explore the effects of changes in women's autonomy within the household as a consequence of war, using a unique panel dataset on Japanese prefectures. Japan experienced a notable decline in the sex ratio after World War II, causing an exogenous shock to the marriage market; thus, drastically altering the power balance between men and women in favor of men. In other words, the negative effect on the positions of wives is greater in regions that experienced severe scarcity in males, and hence, women faced greater difficulty in influencing the family planning of the household.

Our results show that the change in the sex ratio due to World War II had a significant impact on the demographic outcomes in postwar Japan. According to the baseline estimates, the wartime loss of males relative to females accounts for approximately 12% of the increase in the general fertility rate from 1950 to 1970, and approximately 13% of the increase in the child mortality rate from 1950 to 1970. Moreover, a one standard deviation (i.e., 0.03) increase in the wartime loss of males relative to females resulted in a decrease in the height of children at age six by roughly 0.1 cm. These effects partially explain the demographic transition in the postwar period from the perspective of marriage outcomes. This implies that the subsequent remarkable economic development in Japan may have been achieved differently if it had not been for this side effect of the war.[5]

In considering Japan's history to explain the relationship between the change in the gender power balance and the demographic transition, our study is relevant to three streams of literature. First, this study considers demographic changes as the price-adjustment mechanism in the marriage market, represented as an intra-household allocation. Existing studies on the causal effect of the scarcity of men following a war tend to focus on out-of-wedlock children as outcomes of substantive polygamy, which are considered to be the quantity adjustment mechanism for an imbalance in the marriage market

[4]In developing countries, the marriage systems may be based on a polygamous marriage market, in which case there are adjustments to the prices of brides and grooms and to the quantity of each (Becker 1974; Grossbard 1980, 2014).

[5]Although the higher quantity and the lower quality of children generally lead to a slowdown of the economy, the manpower of the baby boomer generation is considered to have underpinned the rapid economic growth in Japan.

(Becker 1973; Grossbard 1980, 2014). However, the Japanese experience in the period immediately after World War II differed from those of other countries in that Japan accepted the fundamental changes to its constitution and legislation that the Allied powers imposed. These changes included the disestablishment of feudalistic family systems. One such change set a new equitable divorce law for both parties, which strictly prohibited having other partners outside marriage. Previously, only wives were punished for such transgressions. A second change was a new unfavorable inheritance law for children born out of wedlock. These changes dissuaded couples from having extra marriages, resulting in a weakened adjustment mechanism in the marriage market. Although the Allied powers considered these constitutional changes as a form of female empowerment, they led to an unfavorable marriage market that was highly likely to reflect in intra-household allocations, including family planning goals. Indeed, significant increases in out-of-wedlock children as a form of polygamy were relatively common after wars in France, Germany, and Russia, due to the scarcity of men (Brainerd 2007; Abramitzky et al. 2011; Bethmann and Kvasnicka 2013). However, the number of out-of-wedlock children remained low in Japan, even after the war. Thus, our study provides a new reference for the consequences of male scarcity in cases of more stringent marriage market adjustment mechanisms.

Second, the study assesses the effect of the sex ratio in the marriage market on the quality and number of children. Here, we use the second of the aforementioned points related to the price adjustment. Cigno (1998) implies that the positive relationship between births and the infant mortality rate reflects the quantity-quality trade-off when parents can influence the survival rate of their children using the resources they spend on their children's health. If demographic decisions are made within a marriage relationship and that there exists a conflicting preference between the husband and the wife, we can expect that a change in the power balance within the marriage will lead to a change in the same direction for both the fertility rate and infant mortality rate. We also explore the effect on the height of children as an alternative measure of the quality of children. A few related studies attempt to explain the height of children as an outcome of intra-household bargaining, citing the nutritionists' consensus that the nutritional status of infants can influence their entire lives (Thomas 1994; Duflo 2003; Brainerd 2007). Health conditions in childhood determine welfare in adulthood, because most diseases can be prevented by improving nutrition, especially in developing countries. Furthermore, physical strength is important in labor market evaluation (Strauss and Thomas 1998). To the best of our knowledge, this is the first study to theoretically and empirically investigate the effect of changes in the marriage market on intra-household bargaining decisions for the trade-off related to the quantity and quality of children.

Third, as technical points, we sought to solve the endogeneity issue in the empirical analysis. Previous studies have explained the relationship between gender empowerment and demographic transitions; however, they tend to have problems with endogeneity because of the properties of the empowerment factors. Angrist (2002) uses immigrant flow as a natural experiment, while others employ data covering the war period to explain how marriage outcomes became unfavorable to women following the scarcity of men after the war (Brainerd 2007; Abramitzky et al. 2011; Bethmann and Kvasnicka 2013). To solve the potential endogeneity issue, we follow the latter strategy, and use the regional variations in the exogenous wartime loss of males relative to females based on a comparison of the sex ratio before the Sino-Japanese War in 1935 to the sex ratio after the war in 1947.

The rest of this paper proceeds as follows: In section 2, we explain the historical background both before and after World War II in Japan. In section 3, we derive the theoretical hypotheses. Section 4 presents the regression analysis to identify the effect of the imbalance in the marriage market on households' family planning choices, following the exogenous shock of the war.

# 2 Background

## 2.1 Fertility and the sex ratio

Japan's postwar move toward democracy, led by the General Headquarters of the Allied Powers (GHQ), saw women gain the right to vote in 1945, as well as the promulgation of a new Japanese Constitution in 1946, which provided for equality of the sexes. However, a remarkable consequence of the war was the loss of a large number of males, causing an imbalance in the sex ratio in society. We hypothesize that the exogenous changes in the sex ratio in the marriage market increased the fertility rate in the postwar period.

First, we provide an overview of the transition of the fertility rate and the sex ratio during the demographic transition in Japan. The solid line in Figure 1 shows the time-series plots of the crude birth rate (CBR), i.e., the number of live births per 1,000 people, from 1915 to 2010. Japan experienced three phases of decline in the fertility rate.

The first phase is the moderate decline in the crude birth rate from around 1920 to before the outbreak of the war. The crude birth rate declined by 5.31 per mille, from 36.19 in 1920 to 30.88 in 1937. Because the crude birth rate increased during the war due to the wartime regime, the overall fertility rate before the end of the war had remained at a higher level than that in the postwar period. Although the middle class in urban areas adopted the idea of birth control around 1930 (Kurushima 2015, p. 212), a continuous

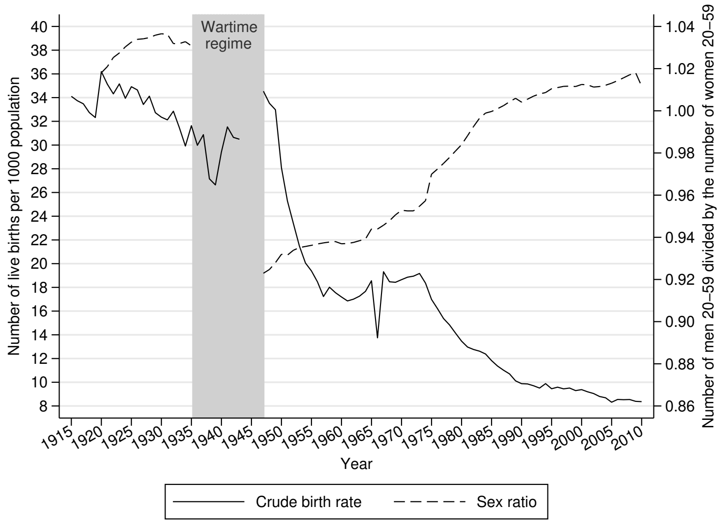



Figure 1: Crude birth rates and the sex ratio

Notes: The crude birth rate is the number of live births per 1,000 population. The sex ratio is the number of men aged 20–59 divided by the number of women aged 20–59. The two ends of the wartime regime (highlighted in gray) represent 1936 and 1947, the years marking the beginning of conscription and the end of the repatriation, respectively. Sources: The number of live births and the number of people are provided by the Statistics and Information Department, Minister's Secretariat, Ministry of Health and Welfare (1999); the number of men and the number of women are taken from the database of the Statistics Bureau, Ministry of Internal Affairs and Communication, described in Online Appendix B.

decline in the fertility rate was not observed until the end of the 1940s.[6] Despite the subsequent decline in the rate, until the 1960s, Japan experienced a long-run baby boom. The second phase is the dramatic decline in the crude birth rate after the end of the war to before 1970. Although the crude birth rate remained high in the years soon after the war (34.54 in 1947), it had reduced by half (17.19) by 1960, where it remained until the beginning of the 1970s. Clearly, the crude birth rate at the end of the 1940s reached the 1920 levels because returnees and repatriated soldiers returned home or married. As such, 8.06 million babies were born between 1947 and 1949 (Ogino 2008, p. 142). Note that the CBR in Japan right after the war was at its highest, followed by its nearly monotonic decline until the 1960s. This trend is evident not only in the measure of CBR but also in another measure, namely, the total fertility rate (TFR), which can be used for comparison with other studies.[7] This Japanese trend is different from that in the US, which showed a moderate increase in TFR, reaching a peak in 1955. While Doepke et al. (2015) attempt to explain the US case with the reduction in opportunity cost of female workers, who were latecomers in the post-war labor market (discussed in detail in Section 5), it seems difficult to use the same explanation for Japan, which witnessed sharp and immediate

[6]The details of the trends in birth control during the pre-war period are described in Appendix A.1.

[7]The annual data of Japanese TFR is stably and continuously available from 1947. The TFR was 4.54 in that year, the highest in the post-war period, 3.65 in 1950, 2.37 in 1955, and 2.00 in 1960.

responses in both CBR and TFR after the war. The third phase from 1970 to current times is characterized by a slow reduction in the crude birth rate. The crude birth rate declined continuously from 18.65 in 1970 to 8.37 in 2010.

This study focuses on the first and second phase of the demographic patterns. Here, we seek to explain the mechanism behind the baby boom and the dramatic decline in the fertility rate observed in the second phase of the demographic transition. To describe this mechanism, we highlight the polarity of the transition state of the sex ratio, which is in line with the decline in the fertility rate in postwar Japan. As illustrated in the dashed line of Figure 1, the time-series plots of the sex ratio (i.e., the number of men aged 20–59 divided by the number of women aged 20–59) shows an opposite trend to the crude birth rate. While the sex ratio in the pre-war period stayed around 1.03, it declined to 0.92 in 1947, indicating the substantial wartime losses of males.[8] Moreover, the sex ratio stayed below 0.95 until 1970, and began to recover from the late 1970s. This historical fact is striking because it suggests that the larger exogenous losses of males than females during the war had highly persistent effects on the gender composition in postwar Japan.

The clear opposite trend between the fertility rate and the sex ratio observed during the demographic transition in Japan implies that mechanisms in the marriage markets affected the decisions of people to have children, as discussed in the Introduction.

## 2.2 Marriage market

Our study is based on the idea that the position of women became unfavorable within households, because of the imbalance in the sex ratio in the marriage market. To understand whether women did indeed face difficulties in finding suitable partners in the marriage market at that time, we first examine the unmarried rate and the age of first marriage, which are used in the literature as variables to illustrate the situation in the marriage market.

First, the unmarried rates for both men and women increased as the war intensified, because of the military draft and evacuations. In the postwar period, the female unmarried rate showed a smooth increase. The rate of unmarried women aged 20-24 increased from 53.5% in 1940 to 55.2% in 1950, while that for women aged 25-29 increased from 13.5% to 15.2% in the same period. In contrast, the unmarried rate of males dropped in the postwar period from 90.8% in 1940 to 82.7% for those aged 20–24, while that of males

[8] The sex ratio decreased sharply after 1937, when the wartime regime began to draft men into the army, and dropped to 0.95 in 1940, just before the start of the Pacific War, reaching less than 0.8 by the end of the war in 1945. The sex ratio recovered dramatically by 0.13, from 0.79 in 1945 to 0.92 in 1947. This considerable change within a relatively short time was undoubtedly caused by repatriated soldiers (Online Appendix B for further details). Importantly, most of the repatriation had finished by 1947, after which the sex ratio barely increased.

aged 25–29 declined from 41.9% to 34.3% in the same period. These findings imply that the war resulted in men finding it relatively easy to meet a partner, but it had the opposite effect for women, likely due to the scarcity of males after the war.

Second, for women, the age of first marriage dropped from 25.0 in 1943 to 22.9 in 1947 (Appendix A.2). It also decreased temporarily from 29.5 to 26.1 for males, with a relatively larger change (3.4 years) than for females (2.1 years). Consequently, the gender gap in the age of first marriage narrowed in the postwar period by almost one year compared to that of 1943.

These two findings are partially consistent with existing empirical studies on the shocks of war on a marriage market. For instance, Brainerd (2007) found that Russian women tended to have lower rates of marriage in regions highly affected by deaths from World War II. Abramitzky et al. (2011) found that the marriage rate of French women who experienced World War I in their most marriageable period decreased, while that of males increased. Moreover, on average, postwar brides married at a slightly older age than did pre-war brides, resulting in a smaller age gap between brides and grooms. In addition, this effect was found to be larger in regions with a higher military mortality rate of men. From these findings, we can expect that such unfavorable postwar situations in the marriage market also apply to Japanese women after World War II.

How does the marriage market adjust if one party finds it difficult to find a partner because of an imbalance in the sex ratio? Becker (1974) suggests that adjustment measures can be classified by quantity (how many partners one marries) and price. Polygamy is an example of an adjustment mechanism in the former dimension. As many studies have argued, the scarcity of one party may lead to multiple marital relations, or even non-marriage relationships. A proxy for this effect is the number of children born out of wedlock (Becker 1974, 1981; Grossbard 1980; Bergstrom 1994; Willis 1999; Neal 2004).

Previous empirical studies support the positive causal effects of the imbalance in the sex ratio due to the war on the ratio of out-of-wedlock children. Brainerd (2007) found that the ratio in Russia increased to 17%, on average, in 1959, while that in the US was 5.3%, over much the same period (1960). Abramitzky et al. (2011) show that, in France, regions with a higher military mortality rate after World War I of 20% had a 1.5% higher ratio of out-of-wedlock children than regions with a military mortality rate of 10%. Kvasnicka and Bethmann (2013) indicated that Germany experienced an increase in out-of-wedlock children from 7.6% to 16.4%, on average, from 1939 to 1947.

Although many industrialized countries showed increases in their ratios of out-of-wedlock children because of polygamy after a shock to the marriage market, Japan showed a different trend. In fact, Japan was already demonstrating a downward trend in out-of-wedlock children before the war. The ratio of out-of-wedlock children in Japan was

7.3% in 1925, which decreased to 6.4% in 1930, and to 4.1% in 1940. This value dropped further to 3.8% in 1947, and has been decreasing ever since.[9] Japan experienced changes to legislation that limited non-marital relations for both parties and introduced an unfavorable inheritance law for out-of-wedlock children.[10] These changes are considered to have decreased the ratio of out-of-wedlock children.

Given the abovementioned historical background, we expect the imbalance of the sex ratio to be resolved through household allocations, including choices with regard to the quality and quantity of children, due to the household bargaining decision process based on gender bargaining power determined in the marriage market.

# 3 Theory

This section provides a theoretical model of intra-household bargaining over family planning, which we use to obtain predictions for the empirical analysis in the following sections. Suppose an economy consists of firms and households. The economy is populated by two gender groups ($i = f, m$), where $N_m$ is the number of men and $N_f$ is the number of women. Individuals have the same preference within each gender group and form a family under a monogamy marriage system. We assume that every individual enjoys higher utility from being married than from remaining single.[11] To reflect the historical background of the Japanese postwar period, our model does not allow having partners outside marriage without ending the relationship with the current partner (divorce). However, we assume that divorce incurs a prohibitively high cost for individuals in this period in Japan, allowing us to focus on the behaviors of married couples. The households make decisions on resource allocations through intra-household bargaining.

## 3.1 Household

### 3.1.1 Preference

Individuals perceive the utility from their private consumption, the number of children, and the quality of children. Following previous studies, there are different preferences for

[9] Today, apart from different historical and cultural backgrounds and meanings of out-of-wedlock children, the ratio of children born out of wedlock is quite low in Japan, at 2.3%, while the average ratio of OECD countries was 39.9% in 2014.

[10] Becker (1974) shows that the demand for wives is higher under polygyny than under monogamy, and that for a given supply of women, their market value and access to marital income will increase. Thus, he claims that laws against polygyny reduce the "demand" for women, and thus, reduce their share of total household output, while increasing that for men.

[11] This assumption corresponds to the interpretation in Nash bargaining that the reservation utility of marriage (i.e., the single state) is lower than the utility levels achieved by any bargaining outcomes under marriage.

the trade-off between children's quantity and quality between men and women, and that women place greater weight on the quality of children than men do. Women with higher autonomy over the household resources—both in developed and developing countries—lead to a higher quality of children. For instance, in the UK, the policy reform of intra-household transfer in terms of child allowance from husbands to wives increases the expenditure on goods for children (Lundberg et al. 1997). Thomas (1990) considered children's health conditions in Brazil as a bargaining outcome and observed that the stronger control of wives over household resources significantly improves the child mortality rate. He also found that the positive effect on the height of children, engendered by an increase in the control of wives over household resources, is much larger than is brought about by husbands. Using an Indian household dataset, Maitra (2004) observed that women's control over household resources increases the household demand for children's health care investment, improving the child mortality rate. These findings allow us to justify our assumption. Moreover, some theoretical studies also employ this assumption, in line with the existing evidence. Several interpretations underline the fact that women tend to assign higher weight on the expenditure for each child. First, it simply originates from the biological gender differences in parental altruism (Eswaran and Kotwal 2004). Biologically, female fertility is constrained while male fertility is relatively unconstrained. Another biological reason can be that males cannot be completely sure whether the child is theirs, which is known as "parental uncertainty." Second—while we do not explicitly set this assumption—the asymmetric biological and social costs of having several children naturally lead females to increase the resources for each child rather than to increase the number of children, given the household resource constraint. We describe this situation by setting the heterogeneity in family goals, captured by the preference weights for the quality of children, $\varphi_i$, following Rees and Riezman (2012). Specifically, we define individual $i$'s utility function as follows:

$$u_i(x_i, n, q) = \ln x_i + \phi \ln n + \varphi_i \ln q,$$

where $x_i$, $n$, and $q$, are individual $i$'s private consumption, the couple's number of children, and the quality of their children, respectively. The assumption of heterogeneous values of $\varphi_i$ can be interpreted in many ways. For instance, it is commonly observed that women are more altruistic with regard to children's welfare, represented as money spent, the level of human capital, and the health status of each child. We can also interpret this to mean that the asymmetric cost of having children leads to women placing greater weight on the quality rather than the quantity of children. With limited medical treatment, giving birth to a large number of children is dangerous for women. Moreover, as Cigno (2012) notes, career interruptions, even just during the puerperal period, can lead to an economically unfavorable situation, not only in the labor market, but also within the household. These conflicting preferences are observed in both developed and developing countries, as documented in Doepke and Kindermann (2014).

The welfare function of the household is given by:

$$\Omega = \theta u_f + (1-\theta)u_m,$$

where the household's objective function is the sum of the utilities of the husband and the wife, weighted by the wife's bargaining power, $\theta$. This specification follows the collective model presented by Apps and Rees (1988) and Chiappori (1988, 1992). In this setting, the household objective corresponds to the wife's utility function when $\theta = 1$, and to the husband's utility function when $\theta = 0$. To guarantee the positive values of the endogenous variables, we further assume in the following analysis that $\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m] > 0$.

### 3.1.2 Constraints

Each individual is endowed with one unit of time. Men supply all their time to market work, while women allocate their time between market work and childcare. [12] The total time spent on childcare is

$$T = tn,$$

where $t$ is the maternal attention required for each child. Thus, the time constraints of the individuals are as follows:

$$L_m = 1,$$
$$L_f = 1 - T,$$

for males and females, respectively. In addition to the opportunity cost of the mother's attention to the children, parents spend their resources on childcare. Denote $q$ as the investment in the quality (e.g., health, education) per child. Thus, the marginal cost of having children is given by

$$C = bq + w^f t,$$

where $b$ is the price of one unit of a child's quality. The budget constraint of the household then becomes

$$x + n(bq + w^f t) \leq w^f + w^m,$$

[12]The assumption that only women take responsibility for childcare is justified if the time spent by mothers and fathers are perfect substitutes, and if the women's wage rates are lower than their husbands.

where $x = x_f + x_m$. The above equation means that the couple allocates their full income to enjoy their own consumption and the number and quality of their children.

### 3.1.3 Demand functions

Solving the welfare function of the household, subject to the budget constraint, yields the following demand functions for males and females, respectively:
*Private consumption*

$$x_f = \frac{\theta}{1+\phi}\left(w^f + w^m\right)$$
$$x_m = \frac{1-\theta}{1+\phi}\left(w^f + w^m\right)$$

*Quantity of children*

$$n = \frac{\{\phi - [\theta\varphi_f + (1-\theta)\varphi_m]\}}{1+\phi}\frac{\left(w^f + w^m\right)}{w^f t} \equiv g\left(\theta; w^f, w^m\right)$$

*Quality of children*

$$q = \frac{[\theta\varphi_f + (1-\theta)\varphi_m]}{\phi - [\theta\varphi_f + (1-\theta)\varphi_m]}\frac{w^f t}{b} \equiv h\left(\theta; w^f, w^m, b\right).$$

Note that the partial effects of the bargaining power of women on household decisions are given by $\frac{\partial x_f}{\partial\theta} > 0$, $\frac{\partial x_m}{\partial\theta} < 0$, $\frac{\partial n}{\partial\theta} < 0$, and $\frac{\partial q}{\partial\theta} > 0$, which indicates that an increase in women's bargaining power leads to a more favorable allocation for wives, with more private consumption among women and less among men. The partial effect leads to a decrease in the number of children while it increases the quality of children.

## 3.2 Bargaining power

In our model, two elements determine the bargaining power of women: relative labor wages ($\frac{w^f}{w^m} \equiv W$) and the sex ratio ($\frac{N^m}{N^f} \equiv \sigma$), as follows:

$$\theta = l\left(\sigma, W\right).$$

Let $\theta_N$ denote the partial derivative of the function $\theta$ w.r.t. its $N$th argument in the equation and $\theta_1 > 0$ and $\theta_2 > 0$ are assumed.[13] These elements affect the outside options

[13]Chiappori et al.(2002) shows other elements of legislation systems. Legislation systems can lead to a favorable position for one party, depending on whether they are utilitarian or egalitarian systems (Chiappori et al.2002; Doepke and Tertilt 2009; Fernandez 2014; Cigno 2012). If the latter is employed by the state, the party in the economically unfavorable position can secure a certain level of income, even

of each spouse. More precisely, these factors influence the levels of utility in the case of a breakdown in negotiation. Although our specification based on the collective model does not specify a bargaining process and does not focus on the outcome in the case of a breakdown, formally described in the Nash bargaining model, it is well known that the factors that alter the threat-point (i.e., the outside options) determine the bargaining positions of the agents.

For example, theoretically, if the sex ratio of a gender group is relatively small, they do not need to stay with their current partner, because they can easily find a new partner in the marriage market (Chiappori et al. 2002; Amuedo-Dorantes and Grossbard 2007; Rapoport et al. 2011). If the spouse can earn a higher income or inherits wealth from their parents, which secures a certain standard of living without a marriage, this leads to a stronger bargaining position within the marriage. A growing body of evidence on intra-household allocation rejects the pooling hypothesis, implying that greater disposable income lets them reflect their intentions in terms of household decisions (Schultz 1990; Thomas 1990; Bourguignon et al. 1993; Phipps and Burton 1998).

Although bargaining power is predicted to be influenced by many elements and that relative economic power plays a substantial role in determining it, we do not treat $W$ as our primary focus in the empirical analysis. One reason for this is that our prediction expects the effect of bargaining power due to an increase in female wage rates to have the same sign as the price effects. The second is that data on strict regional variations of wage rates are limited for the target period, as we discuss later. Thus, we focus on the effect of $\sigma$ and use $W$ as the control variable in our analysis.

## 3.3 Comparative statics

This subsection analyzes the effects of exogenous changes in economic circumstances on endogenous variables. The total effects of the exogenous variables on the number of children are derived as follows (Online Appendix C):

$$\begin{aligned}
\frac{dn^*}{d\sigma} &= \frac{\partial g}{\partial \theta}\frac{\partial l}{\partial \sigma} < 0,\\
\frac{dn^*}{dw^f} &= \left(\frac{\partial g}{\partial w^f} + \frac{\partial g}{\partial \theta}\frac{\partial l}{\partial w^f}\right) < 0,\\
\frac{dn^*}{dw^m} &= \left(\frac{\partial g}{\partial w^m} + \frac{\partial g}{\partial \theta}\frac{\partial l}{\partial w^m}\right) > 0.
\end{aligned}$$

The effect of the change in the sex ratio (an increase in the share of men) on fertility is negative, resulting from the change in bargaining power. An increase in the sex ratio

after a divorce (break-down of the marriage).

decreases the bargaining power of men, because it becomes more difficult for them to find a partner in the marriage market, followed by a reduction in their bargaining power. Consequently, the household chooses a smaller family size, reflecting the smaller ideal family size of the female.

We can also argue the effects of other exogenous variables, the data of which are available for empirical analysis. From the above equations, an increase in female wages is decomposed into price and bargaining power effects. The price effects contain both positive and negative effects. The positive effect comes from the income effect, while the negative effect is a substitution effect due to the higher opportunity cost of a mother's attention to her children. In our specification, the former positive effect is dominated by the latter negative effect. Moreover, an increase in female wage rates allows women to have a say in the household, causing the second negative effect as an outcome of intra-household bargaining. Thus, an increase in female wage rates allows them to reflect their intention to improve the quality of their children (rather than the quantity). Thus, the sign of the total effect of female wage rates on fertility is negative. On the other hand, a change in male wage rates yield two effects on $n$. The first is a direct positive income effect on $n$. The second is the effect of bargaining power due to a change in the relative wages of the couple. Because men place a relatively greater (lower) weight on the quantity (quality) of children, greater autonomy for husbands leads to larger family sizes. Thus, the overall effect is predicted to be positive.

The effects on the quality of children yield similarly, (Online Appendix C):

$$\frac{dq^*}{d\sigma} = \left(\frac{\partial h}{\partial \theta}\frac{\partial l}{\partial \sigma}\right) > 0,$$
$$\frac{dq^*}{dw^f} = \left(\frac{\partial h}{\partial w^f} + \frac{\partial h}{\partial \theta}\frac{\partial l}{\partial w^f}\right) > 0,$$
$$\frac{dq^*}{dw^m} = \left(\frac{\partial h}{\partial \theta}\frac{\partial l}{\partial w^m}\right) < 0.$$

The effect of the sex ratio is explained as follows: when the ratio of men in the marriage market increases, it becomes more difficult for them to find a marital partner. Thus, there are fewer marriage options (outside options to the current marriage). This leads to larger autonomy for women in the marriage, and thereby, a rise in the quality of children, reflecting their intentions.

The effects of female wage rates on the quality of children is explained by two channels. The first is the direct positive substitution effect in the quantity—quality trade-off due to the increase in the relative price of children's quantity. The second effect is derived from the change in bargaining power. Because female wage rates are considered to have a positive effect on female bargaining power, this induces a higher quality of children, reflecting female intention in household decisions.

An increase in male wage rates has a negative effect on the quality of children. In our specification, male wage rates do not change the quality of children by means of price effects. However, the negative effect of intra-household bargaining is caused by the changes in wages. An increase in male wage rates leads to an increase in the bargaining power of males, whose preference weight on child quality is smaller than that of their wives.

We summarize the theoretical predictions of our primary focus as follows: *An increase (a decrease) in the sex ratio of men leads to a decrease (an increase) in fertility, but leads to an increase (a decrease) in the quality of children.*

# 4 Empirical analysis

## 4.1 Data

### Changes in the sex ratio: The wartime loss of males

The recent sociological studies by Watanabe (2014a, 2014b) investigated the draft system in detail and found that the draft tended to be conducted randomly during the Pacific War. We then use exogenous changes in the sex ratio across prefectures, before and after the war, instead of the military mortality rate itself.[14] Although data on the number of casualties due to the war are limited in our case, the third national Population Census (3rd Census) conducted in the mid-1930s and the Extraordinary Population Census (EPC) in 1947 show the loss of males in each prefecture during the war.

As discussed in Subsection 2.1, the sex ratio, defined as the number of males aged 20–59 divided by the number of females aged 20–59, dropped sharply from the outbreak of Second Sino–Japanese War in 1937 to the end of the Pacific War in 1945 (Figure 1). The sex ratio decreased by 0.24, from 1.03 in 1935 to 0.79 in 1945. Then, the sex ratio increased by 0.13, from 0.79 in 1945 to 0.92 in 1947, owing to repatriated soldiers. Almost all of the repatriation was finished by 1947, and the sex ratio remained much the same until after 1948. The sex ratio of people aged 20–59 stayed below 0.95 until 1970, after which it began to recover. Nevertheless, the sex ratio was affected by the internal migration after the war.

[14] The identification strategy used in this study is similar to that employed by Abramitzky et al. (2011). To study the impact of male scarcity on marital assortative matching and other marriage market outcomes, they utilized the geographical variation of the military mortality rate across départments during World War I in France.

Considering these findings, we define the loss of males relative to females during the war, as the sex ratio of people aged 15–59 in 1947 minus the sex ratio of people aged 15–59 in 1935.[15] We obtain the number of people aged 15–59 in all prefectures other than Okinawa prefecture in 1935 and in 1947 from the final report of the 3rd Census and the 5th Population Census, respectively.

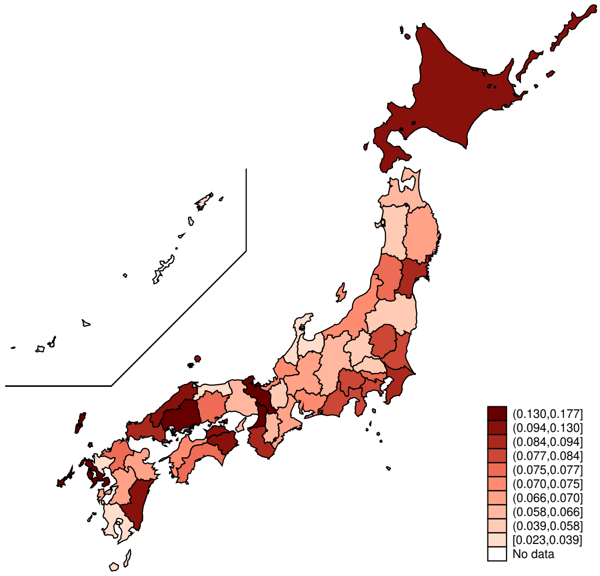



Figure 2: Spatial distribution of the changes in the sex ratio between 1935 and 1947

Notes: The darker shade indicates higher losses of males during wartime. The change in the sex ratio is defined as the sex ratio of people aged 15–59 in 1947 minus the sex ratio of people aged 15–59 in 1935. The sex ratio is the number of males divided by the number of females. We exclude data on the sex ratio in Okinawa prefecture because of data limitations. Sources: Statistical Bureau of Cabinet (1939); Bureau of Statistics, Office of Prime Minister (1955).

Figure 2 shows the spatial distribution of the losses of males relative to females. As we describe the absolute value of the changes in the sex ratio, the darker shade corresponds to the higher losses of males during wartime. Clearly, there is considerable heterogeneity in this ratio, and no obvious spatial correlation or geographical concentration across prefectures. The smallest decrease in the sex ratio is 0.023, in Toyama prefecture, and the largest is 0.177, in Osaka prefecture. Among the six prefectures with large cities, there were substantial variations in the changes in the sex ratio: 0.061 in Hyogo; 0.070 in Aichi; 0.076 in Tokyo; 0.084 in Kanagawa; 0.134 in Kyoto; and 0.177 in Osaka. These figures confirm that the loss of males was not limited to provincial urban areas. The

[15]This means that our main variable could also capture the changes in the sex ratio due to air attacks on the Japanese archipelago during the war. Potential issues with our main variable relate to rumors about areas exposed to atomic bombs and physical disruptions due to the attacks. These might correlate with the changes in the sex ratio during the period just before and after the war. Although we do not report the full results, we have confirmed that our main results remain largely unchanged if we include the interaction term between the air-attack death rate and the post-war dummy (Online Appendix B).

above findings suggest a large random component to the loss of males relative to females in the prefectures at that time.

Table 1: Summary statistics

| | Observations | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Dependent variables | | | | | |
| General fertility rate | 1518 | 109.36 | 44.79 | 40.32 | 220.55 |
| Child death rate | 1518 | 10.66 | 10.11 | 0.75 | 41.27 |
| Boys' height at age 6 | 1426 | 110.57 | 2.17 | 106.70 | 115.17 |
| Girls' height at age 6 | 1426 | 109.57 | 2.22 | 105.70 | 114.37 |
| Variables of interest | | | | | |
| Changes in the sex ratio | 46 | 0.08 | 0.03 | 0.02 | 0.18 |
| Postwar dummy | 35 | 0.66 | | | |
| Control variables | | | | | |
| People in manufacturing, % of total labor force | 1518 | 21.54 | 8.89 | 8.10 | 48.64 |
| Males in manufacturing, % of male labor force | 1518 | 25.20 | 9.12 | 11.62 | 51.47 |
| Females in manufacturing, % of female labor force | 1518 | 15.91 | 8.63 | 2.74 | 43.05 |
| Male wage rate of, yen per day | 35 | 4.09 | 5.36 | 1.05 | 19.60 |
| Female wage rate, yen per day | 35 | 0.94 | 0.30 | 0.48 | 1.82 |

Notes: Observations are at the prefecture-year level. The total includes 46 prefectures for the period 1925–1970(excluding 1937–1947). The general fertility rate is the number of live births per 1,000 women aged 15–44. The marital fertility rate is the number of live births per 1,000 married women. The child mortality rate is the number of deaths of children aged one to four years per 1,000 children aged one to four years. The change in the sex ratio is calculated as the sex ratio in 1947 minus the sex ratio in 1935. The sex ratio is defined as the number of males aged 15–59 divided by the number of females aged 15–59. The values are normalized by the minimum value. The postwar dummy takes the value of "one" for 1950–1970 and "zero" otherwise. "People in manufacturing" is the number of people employed in the manufacturing industry per 100 working population. "Females in manufacturing" is the number of females employed in the manufacturing industry per 100 working females. "Males in manufacturing" is the number of males employed in the manufacturing industry per 100 working males. The number of employed females, males, and people are interpolated between census years. The wage rate indicates the time-series data of daily wages of workers in the manufacturing industry. Wage rates are deflated by the consumer price index in 1934—1936 (=1). Sources: See Online Appendix B.

### General fertility rate, child mortality rate, and child height

As outcome measures, we use the general fertility rate, child mortality rate, and children's height at age six. The general fertility rate is defined as the number of live births per 1,000 women aged 15–44, and the child mortality rate is defined as the number of deaths of children aged one to four years per 1,000 children aged one to four years.[16] Children's height (in centimeters) is measured at physical examinations in all primary schools in Japan. Accordingly, our data on child height include nearly the entire child population at that time.[17] Following previous studies, we use the fertility rate as a measure of the

[16]For the general fertility rate, we use the number of women aged 15–44 rather than the number of married women. This is because the proportion of illegitimate births to total births is relatively small in Japan, as bigamy is prohibited by law. In fact, the average proportion of illegitimate births (i.e., the proportion per 1000 live births) between 1948 and 1970 was only 1.5% (Cabinet Bureau of Statistics, various years).

[17]For further details on these Japanese physical examinations, see Ogasawara (2017) and Schneider and Ogasawara (2018). Here, we use the height at age six rather than at later ages to capture the instantaneous effects of changes in the marriage market on child height.

consequence of family planning within households in terms of the quantity of children (Doepke and Tertilt 2009). In contrast, we use the child mortality rate and children's height as measures of the quality of children (Thomas 1994; Duflo 2003; Maitra 2004; Brainerd 2007). The data on the general fertility rates are available for 46 prefectures for the 35 years between 1925 and 1970, excluding the period 1937 to 1950.[18] The data on the child mortality rates and heights of six-year-old children are available for the period from 1929 to 1970, except for the period between 1937 and 1949.

### Control variables

We use the share of the manufacturing industry and wage rates in the manufacturing industry as baseline controls in our empirical analysis. We define the share of the manufacturing industry as the number of workers in the manufacturing industry per 100 of the total working population. This variable is interacted with year fixed effects to allow their impact to vary over time in our baseline model. As wage indices, we compile time series of both female and male wage rates. The wage rate of females (males) is interacted with the proportion of female (male) workers in the manufacturing industry obtained from the population census.

In particular, as the theoretical section shows, the wage rates influence households' decisions on the number of children. The male wage rate induces positive income and bargaining power effects on the number of children, whereas, female wage rates have negative substitution and bargaining power effects, and a positive income effect. Although these interaction terms do not directly indicate the wage rates, it may be possible to use them as proxies for labor demand, in the industrial sectors in the prefectures. Given the data limitation of having only the regional variations in the fractions of male and female workers in the industrial sector, we employ this strategy to control for the labor market outcomes, following Naidu and Yuchtman (2013).

Table 1 reports the summary statistics of the variables. We report the details of the procedure and data sources in Online Appendix B.

[18]As the precise number of females aged 15–44 is recorded in the census years (1925, 1930, 1935, 1950, 1955, 1960, 1965, 1970), we linearly interoperated the number of females aged 15–44 in the non-census years. This is because we are interested in the varying effects of the change in the sex ratio in the marriage market on the general fertility rate, as expressed in equation 2. However, we have confirmed that this interpolation does not matter; we obtain virtually the same baseline estimate (i.e., 220 per mille) using the census years (note that in column (1) of Table 2, the estimate is 214 per mille). In Appendix D.2, we have confirmed that our main results are also similar to those obtained using the crude birth rate. However, we do not prefer using the crude birth rate as our main outcome variable because it is more likely to be influenced by the male casualties in the war. Similarly, we do not use the marital fertility rate (defined as the number of live births per 1,000 married women) as our main outcome variable, because this is more likely to be influenced by the existence of women of non-childbearing age.

## 4.2 Empirical strategy and main results

To better identify the relationship between the quantity and quality of children and the changes in the bargaining power of women, we consider the effects of the exogenous, prefecture-specific wartime loss of males. Our estimation equation is as follows:

$$y_{it} = \delta \, Changes_i \times Post_t + \mathbf{x}_{it}'\boldsymbol{\beta} + \nu_i + \lambda_t + e_{it}, \tag{1}$$

where $i$ denotes a prefecture and $t$ denotes a year.[19] The variable $y_{it}$ is either the general fertility rate, child mortality rate, or child height, $Changes_i$ denotes the changes in the sex ratio between 1935 and 1947, $Post_t$ denotes a post-war dummy,[20] $\mathbf{x}_{it}$ is a vector of control variables, and $e_{it}$ is a random error term. The scalar values $\nu_i$ and $\lambda_t$ represent prefecture and year fixed effects, respectively.[21] The control variables include the interaction term between the proportion of all people employed in the manufacturing industry and the year fixed effects, the interaction term between the proportion of men employed in the manufacturing industry and their time-series wage rates, and the interaction term between the proportion of women employed in the manufacturing industry and their time-series wage rates. To tackle the heteroskedasticity and the serial correlation in the idiosyncratic error term resulting from the relatively long period covered by the panel data, we further employ cluster-robust standard errors. These standard errors are clustered at the prefecture level.

The coefficient $\delta$ is our parameter of interest. Its estimate $\hat{\delta}$ measures the increases in births or child deaths, or the decrease in child height in prefectures that lost few males relative to females in the periods during the war and after the postwar reforms were implemented, relative to the same values in the prewar periods. Therefore, we expect this coefficient to be positive for the rates and to be negative for the height of children.

First, Table 2 presents the estimation results for the general fertility rate. The parsimonious specification reported in Column (1) includes prefecture and year fixed effects only. Column (2) reports the estimates for our baseline specification, which includes the interaction term between the proportion of manufacturing workers and the year fixed ef-

[19] From 1925 to 1970, excluding the wartime period (1937–1945) and the period immediately after the war (1945–1947). We confirm the stationarity in our panel dataset. For all outcome variables used in our analysis, several tests reject the null of unit-root non-stationarity (Appendix D.1). Note that we do not use the regression difference-in-differences models using the continuous shock variable. This is because although the approach requires the continuous measure of both sex ratio and outcome variables over time, both data are discontinuous at the wartime period, and thus, the dramatic changes in the sex ratio could not be captured continuously. Moreover, panel data on the continuous measure of the sex ratio are unavailable throughout the sampled period.

[20] This variable takes the value "one" for 1950–1970 and "zero" otherwise.

[21] We specify the model similar to Naidu and Yuchtman (2013), who use the interaction term between the cross-sectional treatment variation and the post-event dummy as a key variable of interest.

Table 2: Effect of the women's bargaining power on the general fertility rate and child mortality rate, by wartime losses of males

| | General fertility rate | | Child death rate | | Boys' height at age 6 | | Girls' height at age 6 | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Changes × Postwar dummy | 213.616* | 84.167* | 21.798 | 23.088** | -2.975*** | -2.838*** | -2.501** | -2.296* |
| | (123.154) | (42.419) | (13.140) | (11.022) | (0.874) | (0.877) | (1.214) | (1.304) |
| Females in manufacturing × Female wage rate | | -0.591 | | -0.031 | | 0.007 | | 0.017** |
| | | (0.354) | | (0.060) | | (0.009) | | (0.007) |
| Males in manufacturing × Male wage rate | | -0.007 | | 0.014 | | 0.002 | | 0.002 |
| | | (0.044) | | (0.009) | | (0.002) | | (0.002) |
| People in manufacturing (× year fixed effects) | No | Yes | No | Yes | No | Yes | No | Yes |
| Prefecture and year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R$-squared | 0.9278 | 0.9778 | 0.9611 | 0.9675 | 0.9762 | 0.9819 | 0.9732 | 0.9784 |
| Number of observations | 1518 | 1518 | 1518 | 1518 | 1426 | 1334 | 1426 | 1334 |

Notes: Wage rate indicates the time-series data of daily wages of workers in the manufacturing industry. ***, **, and * denote statistical significance at the 1% , 5%, and 10% levels, respectively. Standard errors are clustered at the prefecture level. Regressions (1)–(2) are weighted by the average number of females aged 15–44 in each prefecture. Regressions (3)–(4) are weighted by the average number of children (excluding infants) in each prefecture. Regressions (5)–(6) and (7)–(8) are weighted by the average number of males and females in each prefecture, respectively.

fects, and the interaction term between female and male wage rates in the manufacturing industry and the proportions of females and males, respectively, employed in the manufacturing industry. We control for this variable to confirm that the effect of the postwar reform is not confounded by other changes in industrial development in each prefecture over the sample periods.

The estimated coefficients on the interaction term, $Changes_i \times Post_t$, are positive and statistically significant in both specifications. According to Column (1), the coefficient on this interaction term is estimated to be 213.616. This result suggests that a one standard deviation (i.e., 0.03) increase in the wartime loss of males relative to females resulted in a 6.41 per mille increase in the general fertility rate after the war. In other words, an increase of approximately 20% (0.03/0.15) in the sex ratio between 1935 and 1947 resulted in a roughly 6.4 per mille increase in the general fertility rate. When we control for the proportion of people in the manufacturing industry in each prefecture and for female and male wage rates, this effect decreases; however, it remains 84.167 (Column (2)). This implies that an increase of approximately 20% in the wartime loss of males relative to females increased the general fertility rate by approximately 2.5 per mille.

To determine the magnitude of our baseline estimates, we calculate the counterfactual fertility rate in 1970 for each prefecture, assuming the changes in the marriage market had not occurred. The mean of the general fertility rate in our sample prefectures decreased by 53.55 per mille, from 123.55 in 1950 to 70 in 1970. In contrast, the counterfactual value of the general fertility rate in 1970 is calculated as the sum of the counterfactual values of each prefecture, which are computed as the observed general fertility rate in 1970 minus the baseline estimate reported in Column (2), multiplied by the wartime loss of males relative to females (i.e., $\sum_{i=1}^{46}(\textit{Fertility}_{i,1970} + 84.167 \times \textit{Changes}_i)/46$). This simple calculation suggests that the counterfactual general fertility rate in 1970 would have been 63.33, implying that the decrease in the general fertility rate would have been 60.22 (123.55 − 63.33). Thus, the decline in the general fertility rate might have been approximately 112% (60.22/53.55) of the actual decline in the general fertility rate if the changes in the marriage market had not occurred. In other words, our estimate suggests that the general fertility rate would have fallen by 12% more between 1950 and 1970 without the shocks in the marriage market due to the war.

Second, Columns (3)–(4) in Table 2 show the estimation results for the child mortality rate. Columns (3)–(4) correspond to the specifications in Columns (1)–(2) of Table 2. As Column (3)–(4) report, the estimated coefficients on the interaction term, $\textit{Changes}_i \times \textit{Post}_t$, are positive and statistically significant in all specifications. According to the estimate in Column (3), the coefficient on this interaction term is 21.798. When we control for the proportion of people employed in the manufacturing industry and the wage rates in Column (4), this effect remains 23.088, supporting the earlier finding that the change in the sex ratio increased the child mortality rate. This estimate suggests that an increase of approximately 20% in the wartime loss of males relative to females increased the child mortality rate by 0.69 per mille.

We employ a similar calculation to that of the general fertility rate to illustrate the counterfactual child mortality rate in 1970 for each prefecture. The mean child mortality rate in our sample prefectures decreased by 8.48 per mille, from 9.66 in 1950 to 1.18 in 1970. The counterfactual value of the child mortality rate in 1970 is calculated as the sum of the counterfactual values of each prefecture, which are computed as the observed child mortality rate in 1970 minus the baseline estimate reported in Column (3), multiplied by the wartime loss of males relative to females (i.e., $\sum_{i=1}^{46}(\textit{Child mortality rate}_{i,1970} + 23.088 \times \textit{Changes}_i)/46$). This simple calculation suggests that the counterfactual child mortality rate in 1970 would have been 0.03, implying that the decrease in the child mortality rate would have been 9.59 (9.66 − 0.07).[22] Thus, the decrease in the child mortality rate might have been approximately 113.1% (9.59/8.48) of the actual decrease if the changes in the marriage market had not occurred. Conversely, our estimate suggests that roughly 13% of the increment in the child mortality rate between 1948 and 1970 was caused by the scarcity of males after the war.

Finally, Columns (5)–(8) in Table 2 present the results for the height of children at age six. Columns (5)–(6) report the results for boys, while Columns (7)–(8) report the results for girls. The estimates are negative and statistically significant across all specifications. Our estimates reported in Columns (6) and (8) suggest that a one standard deviation

[22] We assign the value zero to negative values in the calculation of the counterfactual child mortality rate.

(i.e., 0.03) increase in the wartime loss of males relative to females resulted in a decrease of roughly 0.1 cm in the height of children at age 6. This result suggests that the decrease in the bargaining power of women might have reduced the nutritional intake of their children.

We present additional checks to assess the robustness of our main results in Appendix D.3. We confirm that the baseline results reported in Table 2 remain largely unchanged if we include the working-age population, coverage of medical doctors, and meteorological factors. This implies that the compensatory responses to the loss of the working-age population in society, public health, potential wealth levels, livability, and meteorologically induced industrial structure do not matter in our analysis (Section 5 for finer details). We also conduct several falsification tests by applying our baseline specification to the pre-war subsample. The results suggest that our key interaction variable does not have statistically significant effects on the dependent variables during the pre-war period (Appendix D.4). This implies that the common trend assumption is plausible in our empirical specification.

### 4.3 Flexible specification

Our baseline specification, given in equation (1), shows the average effect of the change in the sex ratio in the marriage market on the demographic and anthropometric outcomes after the war. We now relax our assumption further and allow the coefficient on the variable of our interest to vary over time. The flexible specification of our model is given by

$$y_{it} = \sum_{j=1925}^{1970} \zeta_j \, Changes_i \cdot I_{jt} + \mathbf{x}_{it}' \boldsymbol{\xi} + \mu_i + \eta_t + \epsilon_{it}, \tag{2}$$

where $\mathbf{x}_{it}$ is a vector of control variables, $\mu_i$ is a prefecture fixed effect, $\eta_t$ is a year fixed effect, and $\epsilon_{it}$ is a random error term. In this specification, we interact the changes in the sex ratio with each year dummy ($I_{jt}$), that is, $\sum_{j=1925}^{1970} \zeta_j \, Changes_i \cdot I_{jt}$. Note that the individual magnitudes of the estimated coefficients ($\hat{\zeta}_j$) are not very important in this specification. This is because the individual estimate shows the magnitude relative to the baseline year, say 1935.[23] Thus, we are interested in the patterns in the estimates over the sample period. We expect the estimated coefficients for the postwar period to be greater in magnitude than are those for the pre-war period. This means that we should observe significant changes in the magnitudes of the estimated coefficients around the end of the war.

[23]Note that if we choose an alternative baseline year, the point estimates change in all models.


Figure 3: General fertility rate in high male loss prefectures
relative to low male loss prefectures, before and after World War II

Notes: The solid and dotted lines show the estimated coefficients and their 90 percent confidence intervals from a regression of the general fertility rate at the prefecture-year level, on the changes in the sex ratio between 1935 and 1947, interacted with the year fixed effects. The baseline year is set to 1935. The control variables in the regression are the same as those in Column (2) of Table 2. Both the prefecture and the year fixed effects are included. Standard errors are clustered at the prefecture level. Regression is weighted by the average number of females aged 15–44 in each prefecture.

Figure 3 illustrates the estimated vector of $\zeta_j$ of equation (2) for the general fertility rate. The impact of the change in the sex ratio increases in the years after World War II, but stays around zero in the years before the war. This discontinuity supports the finding that the scarcity of males after the war contributed to the decline in the fertility rate in postwar Japan. As the same figure shows, the estimated coefficients are particularly larger in magnitude in the early 1950s, where the rate of increase in the fertility rate was extremely high (Figure 1). The coefficients stays around 90 from the late 1950s to the end of our sample period, 1970. This result is quite striking because it suggests that the impact of the unfavorable condition of the marriage market due to the war was persistent, at least until the end of the 1960s.

Figure 4 illustrates the estimated vector of $\zeta_j$ of equation (2) for the child mortality rate. Similar to the general fertility rate, the estimated coefficients are larger in magnitude in the years after World War II, whereas the estimated coefficients stay around zero in the years before the war. Notable effects of the change in the sex ratio on child deaths emerge after 1952, a few years later than the effect on the fertility rate. This finding is consistent with the fact that deaths of children must follow births. In contrast to the effect on the fertility rate, the impact of the change in the sex ratio on the child mortality rate began to diminish around the late 1960s.

A similar pattern is observed for the heights of children. Figure 5 illustrates the estimates for the heights of children at age six. The estimated coefficients are larger in magnitude in the years after the war than during the years before the War, which

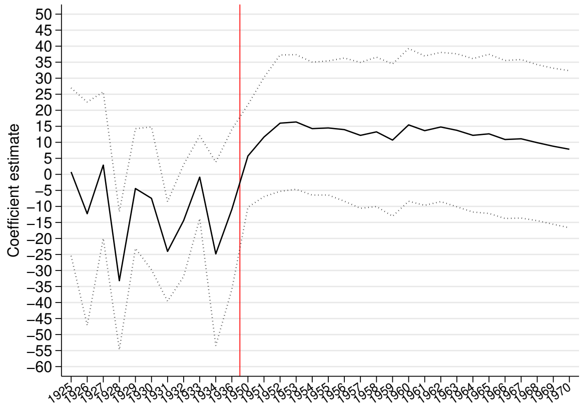
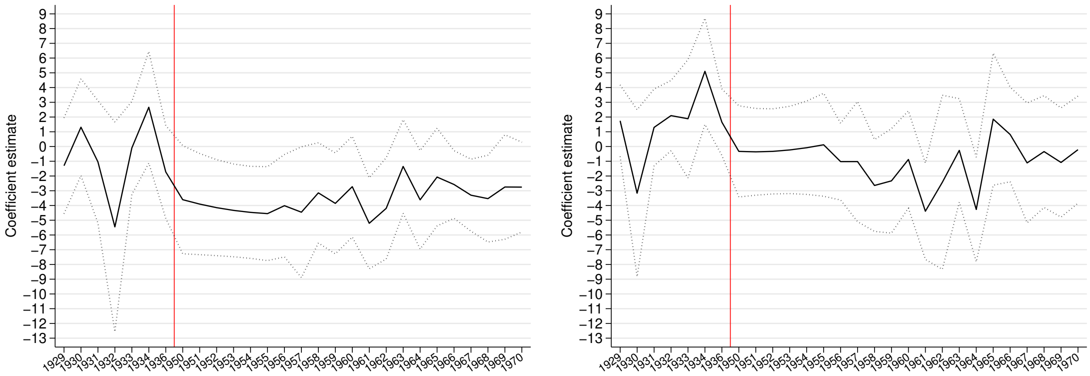



Figure 4: Child mortality rates in prefectures that experienced significant losses of males compared with those that did not, before and after World War II

Notes: The solid and dotted lines show the estimated coefficients and their 90 percent confidence intervals from a regression of the child mortality rates at the prefecture-year level, on the changes in the sex ratio between 1935 and 1947, interacted with the year fixed effects. The baseline year is set to 1935. The control variables in the regression are the same as those in Column (4) of Table 2. Both the prefecture and the year fixed effects are included. Standard errors are clustered at the prefecture level. Regression is weighted by the average number of people in each prefecture.




(a) Boys' height

(b) Girls' height

Figure 5: Height at age 6 in high male loss prefectures relative to low male loss prefectures, before and after World War II

Notes: The solid and dotted lines show the estimated coefficients and their 90 percent confidence intervals from a regression of the height at age 6 at the prefecture-year level, on the changes in the sex ratio between 1935 and 1947, interacted with the year fixed effects. The baseline year is set as 1935. The control variables in the regression are the same variables used in Columns (6) and (8) in Table 2. Both the prefecture and the year fixed effects are included. Standard errors are clustered at the prefecture level. Regression is weighted by the average number of males (in Figure 5a) or females (in Figure 5b) in each prefecture.

is consistent with the results from our baseline specification in Table 2. However, the patterns for height seem to be less clear than are those for the general fertility rate. It is necessary to consider that children's heights at age six are less likely to be influenced immediately by the environment than the heights of infants. Unfortunately, long-term comprehensive data on the heights of infants are not available for Japan. Despite this limitation, we find a clear decrease in the magnitudes of children's heights soon after the end of the War.

Our flexible estimates confirm that in Japan, the effects of the change in the sex ratio in the marriage market had persistent effects on the general fertility rate and the child mortality rate until the late 1960s. We observe a similar persistence in the changes in children's heights. These results are consistent with the hypothesis that the larger exogenous losses of males relative to females due to the war had highly persistent effects on the gender composition in postwar Japan (Subsection 2.1).

In the late 1960s, the second generation of the war had children. Thus, our results suggest that the effect of the shock in the marriage market continued to influence the decisions of the second generation. We can interpret the mechanism behind this long-run effect in several ways. First, we can expect interactions among households through social norms, peer pressure on gender roles, or the bargaining positions within a family. The change in attitude tends to be slower than price changes. Komura (2013) theoretically showed that a new couple anticipates their bargaining positions through the social norms of other couples, such as their parents and couples in the same generation. Recent studies of the intergenerational transmission of custom and behaviors have also found that parents pass down their preferences and customs to their descendants (Fernandez 2007; Fernandez and Fogli 2009; Kawaguchi and Miyazaki 2009; Fogli and Veldkamp 2011; Farré and Vella 2013; Fernández 2013; Johnston et al. 2014). Consequently, new couples in which wives have lower bargaining power (or a more negative attitude toward the labor market) are expected to behave in similar ways to choosing a higher number of children.

Alternatively, the labor market factor could be the second driver to sustain this effect. An insightful study by Doepke et al. (2015) found that the baby boom a little after World War II in the United States could be explained by the increase in female labor supply. According to their theory, regions with a lower proportion of men experienced higher female labor force participation. While this could have improved the labor force participation of women right after the war, the younger women who entered the labor market later suffered from the shortage of demand for female workers. In this case, the lower opportunity cost in the region with higher mobility would have led to a higher number of children for younger women. However, as we discuss in the next section, the latter effect was only valid for the baby boom a little after the war in the United States, and may not explain the baby boom right after the war in Japan.

# 5 Robustness

In this subsection, we discuss the possible effects of shock in the marriage market on fertility and the quality of children in the wartime period; these effects may transmit through a different channel from that in our argument.

## 5.1 Impacts of labor market conditions

The first effect occurs through a simultaneous shock on the labor market. One concern is that variations in the dependent variables derive from a very small working population, which in turn relates to the loss of male workers. In terms of fertility, parents may have a greater incentive to have children, because they will need labor if the region's male population is small after a war. As for the infant mortality rate and the height of children, children would not have been sufficiently fed if few men—who comprised the vast majority of production workers at the time—were engaged in production. Thus, it may be important to determine whether adverse outcomes in these areas were brought on by a scarcity of working population. Therefore, we add as a control variable the damage to the working population in our sensitivity analysis. In our sensitivity analysis—the results of which are reported in Appendix D.3—we include the number of people aged 20–59, to control for responses intended to compensate for society's loss of working-age individuals. Our results remain unchanged when we consider these additional factors.

Many studies document the effects of the postwar scarcity of men on the employment of female workers. Using US data, Goldin (1991) implies that although the end of the war led to large-scale lay-offs among female workers who had comprised the main wartime laborers, there has been a drastic recovery since the 1950s. Acemoglu et al. (2004) also observed this effect, finding that regions with a higher mobilization of men experienced an increase in female employment. Goldin and Olivetti (2013) studied the impact on the employment of female workers, while considering their heterogeneity. Fernandez et al. (2004), in contrast, demonstrate the long-term intergenerational effect of the increase in female employment during the war, stating that it resulted in a change in their sons' preference for marriage to a working woman and improvements in household productivity. The recent study of Gay (2018) classifies the channel of transmission of the attitude toward gender roles, using the upward shift in the female labor supply in France after World War I.

It appears that Japanese women had a similar experience to women worldwide. Although Japan's female labor participation rate was relatively high during the war, female workers were laid off immediately following the men's demobilization; there were gradual improvements to their employment status thereafter. According to Japan's Ministry of

Health, Labour and Welfare (2006), the estimated number of unemployed and demobilized individuals (repatriates included) in November 1945 had reached 13.42 million; this figure represents 30–40% of the total labor force at that time. However, it recovered to 0.8% by 1948, and remained at around 1.0%, following the second peak of 2.5% in the mid-1950s. Thus, there were some qualitative similarities in the labor market of the postwar period, characterized by a high unemployment rate in the aftermath of the war and its relatively prompt recovery.

Given the evidence, it appears that the demand for female employment had improved to a greater degree in those regions that had seen a larger change in the sex ratio (i.e., due to the shortage in labor). If the number of children and the rate of female employment had a negative relationship, regions with a severe shortage of men would be expected to experience a decrease in the number of children. Thus, had we the opportunity to properly control for this effect, we expect that our results regarding the bargaining effect would have been reinforced. Although wage data were not available, we partially control for this by using labor demand versus the employment rate, by industry, as a proxy, in our empirical analyses.

Finally, it is necessary to mention an influential study that examined the relationship between male scarcity in the regions and their fertility rates. Doepke et al. (2015) explained the baby boom in the United States after World War II using the increased female labor force participation in response to the higher labor demand due to higher mobilization. They showed, theoretically, that women in labor markets with a higher mobilization rate engaged in work, which crowded out the labor force participation of younger women (i.e., those who had reached adulthood in the 1950s). As younger women had a lower opportunity cost of having children, the fertility rate could have been higher in these regions. Using US data, the study also supported their theory demonstrating that the baby boom occurred a little after World War II (i.e., five years later). While they showed the mechanisms behind the influence of the higher mobilization rate on the fertility rate in the same direction as our study, the Japanese case differs from the US case in that the Japanese postwar baby boom began right after the war. Thus, we propose a new clarification of the different type of postwar baby boom and add an alternative explanation of the two variables that occurred right after the war.

## 5.2 Widowhood

A significant change in sex ratio seems to relate largely to widowhood after the war; regions with a large number of widows were expected to witness a decrease in child quality, given their economic difficulties. Such a finding would imply that we had overestimated the bargaining effect. Although we do not have prefecture-level data pertaining to the number of widows, which we would have leveraged for controlling purposes, we discuss here the possible impact of widowhood, based on Japanese historical documents from that period.

According to studies of Japanese history, war widows suffered from severe poverty, which pushed them to participate in the marriage market by remarrying. Kawaguchi (2003, p103) documents drastic changes in their living standards, which occurred via two channels, namely, runaway inflation after the war, and the abolition of government economic support for war widows. The GHQ abolished the military pension, with the aim of bringing their war criminals to justice. Although the pension program had served as the main financial resource of widows, as it had been paid to families of the war dead before the end of the war, it was abolished in February 1946. Because the Japanese government could not find any secure remedy for widows who had fallen into poverty because of this abolition, it encouraged the widows to remarry. However, Kitagawa (2000) argues that among widows interested in remarrying, not many actually found a new partner. Thus, we cannot completely exclude the possibility that despite their efforts, some widows could not find a new partner; this may have resulted in an additional negative impact on the quality of children, as mentioned.

Despite the possibility of the negative impacts on the quality of children, note that the number of widows who could not remarry is expected to reduce the number of married couples. Therefore, our results concerning fertility are strengthened by controlling for the severity of widowhood among the regions.

## 5.3 Marriage matching

Previous studies on the change in the sex ratio after war find that causal effects on marital matching are the adjustment mechanism of the price dimension. One possible adjustment mechanism of the price dimension is marital matching. While focusing on heterogeneous classes of new brides and grooms, Abramizky et al. (2011) explored the effects of sex-ratio imbalance on marriage-matching patterns. They found that French women had experienced unfavorable matching in terms of marriage, in that the postwar scarcity of men compelled women to marry partners of a lower socioeconomic status. This result implies that the heterogeneities of agents in the marriage market played a role in the quality adjustment system, in terms of matching in the French marriage market at that time. However, this adjustment may have been more difficult to make in Japan, as it experienced a rapid narrowing of the income gap after the war.

Clio-Infra (2018) reports the Gini coefficients (multiplied by 100) of many major countries, including Japan and France—the latter of which Abramizky et al. (2011) investigated considering World War I. In 1929, Japan had a value of 51.8; this number drastically decreased to 35.9 in 1950, the period after World War II. The historic events behind this trend are documented by Yugami (2003), who lists the following as the main factors that reduced the income gap following World War II: (i) the land reform implemented by GHQ stipulated that the cultivation area per farmer would be limited (Hayashi and Prescott 2008), (ii) the gap in real wages between non-agricultural and agricultural households narrowed, due to a decline in demand for mining and manufacturing products and a relatively excessive demand for food, and (iii) new postwar economic trends reduced the relative real income of high-income individuals (e.g., the destruction of real assets during the war, the depreciation of financial assets due to inflation, and the introduction of a property taxation system). Thus, Japan mainly narrowed its income gap through changes in the social structure.

While the trend of a drastic postwar decline in the Gini coefficient was observed in many other countries (e.g., Italy, the United Kingdom, and the United States), it was not seen in France, which had a much more moderate decline. Its Gini value after World War I, which is the period Abramizky et al. (2011) examined, even showed an increase. In particular, the data show that France's Gini value increased from 54.79 in 1910 to 61.68 in 1929—just over a decade after World War I—followed by a relatively moderate decline after World War II (i.e., 57.91 in 1950). This trend implies that in France, it was ideal to look at marital matching as an adjustment mechanism in the marriage market in the dimension of the price (quality), given that the heterogeneity in income level (or observable properties of possible candidates of marital partners) persisted in the postwar period. In contrast, it was less likely in Japan that the sex-ratio imbalance was adjusted by marital matching in terms of social classes, given the narrowing income gap after the war.

Heterogeneity in the ages of brides and grooms can be used as an alternative factor in marriage matching.[24] The theoretical mechanism can be explained as follows: in general, as younger spouses have a better position in the marriage in front of the alternative marriages with potential partners, they enjoy favorable marriages. However, male scarcity resulted in men having a better position in the marriage market after the War. Given the presence of a typical gender age gap in the first marriage (i.e., the grooms tend to be older than their partners), it was expected to be narrowed; it is more likely to occur in marriages between younger grooms and older brides than in the pre-war period. Abramitzky et al. (2011) investigated the effects of the shock in the marriage market on the spousal age

[24] Although we focus on the effect of the shock in the marriage market on demographic trends in monogamy systems, Neelakantan and Tertilt (2008) comprehensively consider the interdependence among the marriage market system, the spousal age gap of couples, and population growth, treating all of them as endogenous variables. According to their study, the narrowed spousal age gap is likely to coexist with the monogamy system.

gap and age at the first marriage. They found that the age gap in the first marriage narrowed after the war, which is consistent with our findings from Japanese time-series data, as subsection 2.2 shows. Moreover, they also showed that this narrow spousal age gap mainly comes from delay in the first marriage of females, using the French micro dataset. However, such data are unfortunately limited in the context of modern Japan, and thus, we were unable to obtain sufficient data for the statistical analyses presented in the main text.

Hence, this study attempts to add another adjustment mechanism of the price (i.e., intra-household allocation) to the literature on marriage markets in postwar periods. If one considers the effect of marriage matching, it is possible to mitigate the effect of change in the sex ratio on the intra-household allocation. Our results with the significant effects on intra-household allocation without controlling this offsetting effect imply that the actual intra-household allocation can be more responsive than our estimation results, yet still robust.

# 6 Conclusion

This study attempts to explain the demographic transition of Japan from the perspectives of the marriage market and family economics. Specifically, we first developed an intra-household bargaining model where the couple bargains over the quantity and quality of their children. Here, the power balance is determined by the sex ratio in the marriage market. Using the theoretical model, we set two hypotheses: an increase (decrease) in the male–female sex ratio induces a decrease (increase) in the number of children; the reverse is true for the quality of children. Next, we undertook regression analyses using Japanese prefecture-level panel data; additionally, as a natural experiment, we examined the exogenous shock to Japan's marriage on account of World War II.

Many studies have focused on war-induced shocks on the marriage market as events unfavorable for women, and broadly, interpret subsequent demographic trends as consequences of unfavorable conditions for women in the marriage market. These studies generally focus on the effects of the out-of-wedlock children ratio, which is frequently used as a proxy for relations outside of marriage. All these previous studies found that the scarcity of men due to war brought about a significantly higher ratio of out-of-wedlock children in Russia, France, and Germany (Brainerd 2007; Abramitzky et al. 2011; Bethmann and Kvasnicka 2013). However, unlike these countries, Japan after the World War II kept its ratio relatively low, the implication here is that unfavorable conditions were less likely adjusted in terms of the marriage market quantity (i.e., polygamy). Thus, we expect that the scarcity of men in Japan's marriage market to have adjusted in the new quality dimension, namely, intra-household allocation. Existing studies suggest other adjustment mechanisms (i.e., polygamy as a quantity adjustment, and matching as a quality adjustment), and thus, we have attempted to add evidence of a postwar change in the sex ratio as a demographic trend, through the new adjustment mechanism of intra-household allocation. Examining intra-household allocation as a couple's bargaining outcome, we predict that a scarcity of men resulted in a higher fertility rate, reflecting the husbands' intention to have a larger family than their wives wanted. Utilizing a unique property of the marriage market in postwar Japan (i.e., the adjustment of the sex ratio likely reflected or completed in the marriage), we also explored effects on the infant mortality rate and the heights of children, as proxies of quality of children.

Our empirical results show that regions that lost significant numbers of men in the war experienced increases in both the general fertility rate and child mortality rates, and a decrease in the height of children; these findings support our two hypotheses. Our analyses succeed in explaining the counterfactual finding that an imbalanced sex ratio in the marriage market leads to a higher fertility rate (Figure 1). The results also indicate that the exogenous shock of the war on the marriage market persistently influenced intra-household allocations with regard to the quantity and quality of children, until 1970. As most of the demographic decisions around 1970 were made by the second generation following the war, the persistent marriage market effects imply that the gender power of marriage is likely to affect multiple generations, and women incur double costs of war: direct costs, and indirect costs arising from their unfavorable situation in the marriage market in the postwar period. Our findings may apply to developing countries that experience sequential civil wars, implying that wars harm the daily lives of people in the region, and force women to suffer persistent effects through the marriage market.

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# Appendix to "Consequences of war: Japan's demographic transition and the marriage market"

by Kota Ogasawara & Mizuki Komura

# Appendix A Historical background appendix

## A.1 Fertility rate

The solid line in Figure 1 shows the time–series plots of the crude birth rate, i.e., the number of live births per 1,000 people, from 1915 to 2010 in Japan. Japan have experienced three-phase in the decline in the fertility rate. The first phase is the moderate decline in the crude death rate from around 1920 to before the outbreak of the World War II (hereafter, WWII). The crude birth rate declined by 5.31 per mille, from 36.19 in 1920 to 30.88 in 1937. The second phase is the dramatic decline in the crude birth rate after the end of the WWII to before 1970. Although the crude fertility rate remained higher around the years soon after the WWII (34.54 in 1947), it was reduced by half (17.19) in 1960 and stayed roughly equal until the beginning of the 1970s. The third phase is characterized the slow–reduction of the crude birth rate from 1970 to today. The crude birth rate declined continuously from 18.65 in 1970 to 8.37 in 2010. As discussed in Section 2.1, this present paper focus on the first and second phase of the decline in the fertility rate. In this section, we overview the movements and establishment of laws, which might have affected the demographic transition in Japan.

### A.1.1 Before WWII

In 1920s Japan, when the birthrate had declined, interest in birth control was growing. For example, Margaret Sanger's "Philosophy of Sexual Desire and Birth Control" was published in the June 1921 issue of the magazine *Kaizou* (Reconstruction). Moreover, in November 1921, a translation of Sanger's Birth Control was published (Ohota 1976, p. 115-123). In 1922, the president of *Kaizou* magazine, Sanehiko Yamamoto, invited Sanger to Japan. The opposition to Sanger's arrival in Japan was large, and every newspaper reported on it. In 1930, a magazine called *Shufu no Tomo* (Housewife's Friend), which was bought by a large female readership and had published 600,000 copies, also published opinion articles about Sanger's work in America, introducing readers to birth control (Ohota 1976, pp. 124-125). Sanger's arrival in Japan led to a growing birth control movement, spreading information about contraception in the country. For example, in May 1922, the Japan Birth Control Research Association was founded for people such as doctors and scholars in Tokyo, and in 1931, the Japan Birth Control League was founded. In January 1923, the Osaka Birth Control Research Association was founded in Osaka, presenting lectures and publishing pamphlets about birth control. The birth control movement originated in the early 1920s, and in every region, private organizations began publishing materials such as pamphlets and books.

Until the early 1930s, this movement had been growing among the urban middle class

(Kurushima 2015, p. 212). However, the actual effect of the birth control movement on reducing the birth rate may have been small. The reason for this is that publications on topics such as specific birth control methods or how to use contraceptive devices were forbidden due to censorship by the authorities (Ohota 1976, pp. 154-157, p. 189; Norgren 2008, p. 48). Moreover, in 1930, the Ordinance for the Control of Harmful Contraceptive Appliances forbade use of the contraceptive pill, which was considered a potent birth control at the time (Ohota 1976, p. 331). It is therefore difficult to believe that the fall in the birth rate at this time was due to increased use of contraceptives. Rather, what may have been more important was a social change, whereby the notion of a tradeoff between quality and quantity of children spread among women through an awareness of contraception. In fact, a special issue of the aforementioned *Shufu no Tomo* was put together for August 1920, which stated, "We women use this method (contraception) to bring fit children into the world, and after raising our hand-picked selection, leave them to this to the world, thereby living one's own life as one human being, as a woman, as a wife, and as a mother" (paraphrased). This advocates the necessity of women making proactive decisions about the number of children they will have, through contraception.

When the Second World War began, there was strict control over birth control activities. Publications were banned from running articles about birth control. Moreover, the National Eugenic Law was enacted in 1940, and its enforcement from July 1941 onwards banned birth control itself. The object of the National Eugenic Law was "to ensure the improvement of the national character by means of preventing an increase in the number of persons with a predisposition towards malignant hereditary disease and promoting an increase in the number of persons who have sound constitutions" (Article 1), and "persons who have sound constitutions" were banned from receiving contraceptive surgeries, if contraception was the goal. In the same year, the state began publicly recognizing "excellent families with many children," and in January 1941, the "Outline for Establishing Population Growth Policy" was mandated by the cabinet. That outline urged "sharp and permanent population growth and rapid increase in the quality of the population," and set the practical aims of lowering the average marriage age by three years, and achieving an average of five births per household (Fujime 1997 p. 351).[25] The result of these wartime policies was an increase in the birth rate, which, by the late 1930s, had fallen into the 20s, to above 30% in the 1940s (Figure 1).

[25] To achieve this goal, a system was planned for organizations and publicly managed agencies to provide marriage introductions and mediation, reduce the cost of weddings, and lend funds for bride price, as well as suppressing the employment of women over 20, and alleviating employment conditions that restrict marriage. For more detail, see Ogino 2008, p.120-135.

### A.1.2 After WWII

In 1945, immediately after the Second World War, a baby boom was brought on by marriages and the return of family members who had demobilized or repatriated from abroad, and the birth rate increased to the level of the 1920s. In just three years between 1947 and 1949, 8,060,000 children were born, known as the baby boom generation (Ogino 2008, p. 142). However, as shown in Figure 1, the birth rate rapidly dropped in the 1950s to below 20%. From then on, until the beginning of the 1970s, the birth rate remained at about that level.

Research up to now has stated that the approval of abortion by the Eugenic Protection Law, which was enacted on September 11 1948, was a cause of the dramatically reduced birthrate in the 1950s (e.g., Hodge and Ogawa 1991). The object of the Eugenic Protection Law was "to prevent birth of inferior descendants from the eugenic point of view and to protect life and health of mother, as well" (Article 1). In other words, this law was rooted in eugenic ideas: whereas abortion had been a punishable offense until this point, it was decided to permit abortions in order to eliminate inferior descendants (Fujime 1997, p. 358).[26] The same law approved abortion aimed at protecting the health of the mother, and abortion due to "financial reasons" was approved by the first amendment in 1949. The second amendment in 1952 made it possible to carry out abortion purely with the authorization of an appointed physician, as a simplification of the abortion review in order to reduce the number of illegal abortions (Ohota 1976, p. 372).

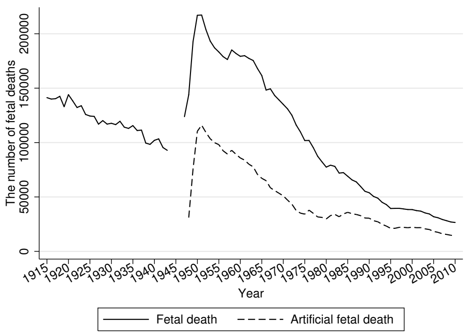
The first amendment in 1949 added stipulations about spreading information about birth control in addition to abortion. Specifically, Article 20 stated that "There shall be set up a Eugenic Marriage Consultation Office in order to give advice in response to consultation on marriage affairs from the viewpoint of eugenic protection, to ensure the dissemination and improvement of the essential knowledge of heredity and other aspects of eugenic protection, and to simultaneously popularize and give guidance in the adequate method of contraception" (Ohota 1976, p. 372; Institute of Population Problems, Ministry of Health and Welfare 1969). The second amendment in 1952 mandated that local authorities establish these and renamed them Eugenic Protection Consultation Offices. At the same time, it stipulated that doctors, midwives, and nurses be trained

[26] Chapter 3 Article 14 of the Eugenic Protection Act defines the scope of abortion permission as follows:1. If the person in question or the spouse has mental illness, mental retardation, psychopathia, hereditary physical disease or hereditary malformation; 2. If the person or the spouse has a relative in blood within the 4th degree of consanguinity who has hereditary mental illness, hereditary mental retardation, hereditary psychopathia, hereditary physical disease or hereditary malformation; 3. If the person in question or the spouse is suffering from leprosy; 4.If the health of the mother may be affected seriously by continuation of pregnancy or by delivery from the physical or economic viewpoint; 5. If the person in question has conceived by being fornicated by violence or threat or while incapacitated to resist or refuse (Fujime 1997, p. 357).

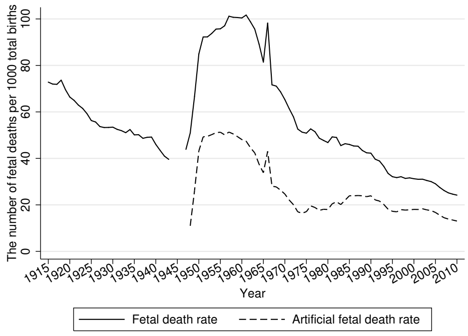
and assigned as instructors in the practice of birth control, and this became the impetus for spreading information about birth control. The promotion of birth control was also connected to the issuance of the new Pharmaceutical Affairs Act that was enacted in July 1948. The new Pharmaceutical Affairs Act approved the manufacture of seven types of contraceptive: papillon, haoma, contra, semoli, contour, sampoon loop, and hinoor (Ohota 1976, p.375). In June 1952, "Birth Control Guidelines" were published for every region of Japan, as a report by the Public Health Director at the Ministry of Health and Welfare. That report explained, "there has recently been a sudden increase in abortions among the population, and the effect this exerts on the life and health of a mother's body should be appropriately considered; therefore, with the following methods, we plan to proactively popularize appropriate birth control from a public health point of view in all parts of society and to improve the welfare and quality of the country" (Ohota 1976, p. 378). However, few municipalities initiated birth control activities responding to the promotion of birth control by the government. Moreover, compared to its relatively progressive abortion policy, Japan's contraception policy was rather conservative. In fact, Japan stood out as being the last UN member-nation to legalize the contraceptive pill, only doing so in 1999 (Norgren, p. 11).

As prior research has pointed out, the spread of information about abortion and birth control contributed to the declining birth rate between 1945 and 1970 (e.g., Yuzawa 2012, pp. 133-135). However, abortion and contraception are specific birth control "technologies" and do not themselves reduce the birth rate. Rather, the fundamental main cause of the reduced birth rate was that married couples in postwar Japan had to make careful decisions, and widespread birth control, through abortion and contraception, meant that couples were making a decision to limit the number of children, by using the "technologies" of abortion and contraception. In fact, Ochiai (2004) has stated regarding the sudden decline in the birth rate in the 1950s, that "it occurred because young married couples intentionally halved the number of children born," and identifies at this time "the beginning of the postwar family structure, whereby it was considered obvious that everybody of suitable age would marry and have 2-3 children, and one hoped to save up enough money to bring up each child." Similarly, Ishizuki (2007, pp. 97-98) explains that, through the spread of information about contraception, women were able to control the number of children according to their own wishes, using birth control. The most important fact is that these kinds of changes in consciousness did not arise before, but only after the war. This strongly suggests that as women acquired various rights through postwar democratic policies, husbands and wives became able to determine for themselves the number of children they wanted to have.

The postwar birth control policies described above were also grounded in the basic policies of the General Headquarters. Colonel Crawford F. Sams, the Chief of the Public Health and Welfare Section of the GHQ, believed from the very beginning in introducing birth control to Japan. At a military medical school in the mid-1930s, General Sams had studied demography from the writings of Warren Thompson, but Thompson had the idea that Japan's aggressive war was due to a population surplus (Thompson 1950). For that reason, Sams also thought that resolving Japan's population surplus was necessary to establish a peace-loving nation. In fact, in a February 1946 interview, Sams explained, "there are three ways to resolve Japan's surplus population: food importation emigration, and birth control through industrialization. Birth control in particular is something we can immediately implement" (Fujime, 1997, p. 359).[27] In other words, event of the legalization of abortion grounded in a eugenic point of view in postwar Japan can be understood as an exogenous shock, similar to the democratization policies of GHQ.




(a) Number of fetal deaths




(b) Fetal deaths rate

Figure A.1: Time series plots of the fetal deaths

Notes: Fetal death includes both artificial and spontaneous fetal deaths. Fetal death rate is the number of fetal deaths per 1,000 total births. Artificial fetal deaths rate is the number of artificial fetal deaths per 1,000 total deaths. The number of artificial deaths are available after 1948. Source: Cabinet Bureau of Statistics (various years).

The reality that abortion suddenly increased after the enactment of the Eugenic Protection Act can be understood based on the contemporary changes in stillbirths. Figure A.1a shows the change in the number of stillbirths from 1915 to 2010. After 1948, when the Eugenic Protection Act was enacted, the number of induced miscarriages due to abortion increased, and so by the early 1950s the number of stillbirths was over 100,000. The number of induced miscarriages fell below 50,000 in the early 1970s and has continued to fall gradually since then. The shift in the proportion of stillbirths shown in Figure A.1b

[27]Moreover, Sams explained this in lectures that he gave when conception and birth control courses aimed at doctors were running at the Ministry of Health and Welfare's Institute of Public Health. Also, a female doctor e belonging to the occupation forces' eighth division, Manitoff, led the implementation of dispensaries at the Institute for Public Health (see Fujime 1997, pp. 359-360). Analyzing the relationship between birth control movement and GHQ in postwar Japan, Fujime (pp. 359-373) explains that the central driver of the birth control movement was the fact that GHQ and Japanese bureaucrats supported a neo-Malthusianism that advocated population control through birth control.

shows a similar change to the number of stillbirths. In a similar way to the reduction of infant mortality, the stillbirth rate has been gradually falling since the 1920s. However, it increased sharply after the enactment of the Eugenic Protection Act and after dropping sharply in the 1960s, has continued to fall gradually since the 1970s.

## A.2 Unmarried rate and age of first marriage

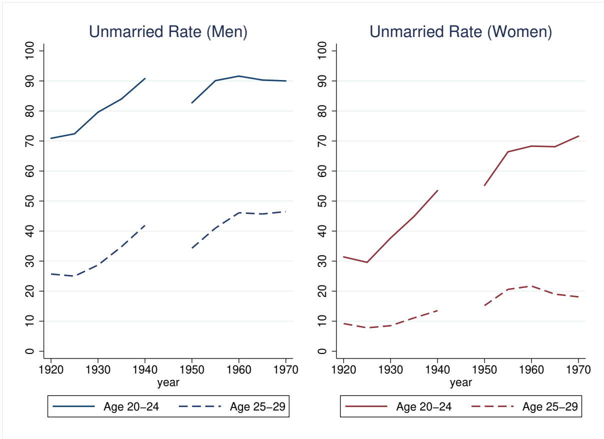



Figure A.2: Unmarried rate by gender

Notes: Unmarried rate is the proportion of individuals in the population who never married. Sources: Population census (Online Appendix B).

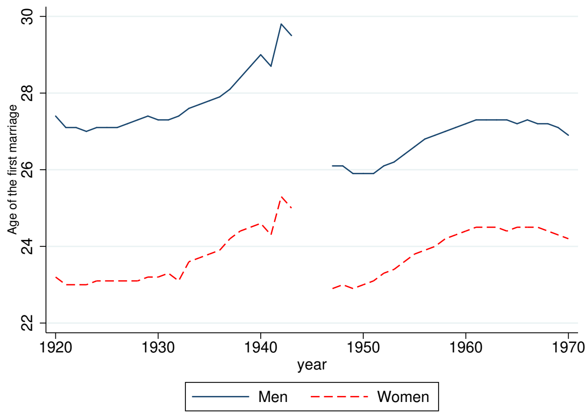



Figure A.3: Age of first marriage by gender

Note: This figure shows the average age of individuals when first married. Wartime data are not available. Source: Vital Statistics of Japan (Online Appendix B).

Figure A.2 indicates the rates of unmarried men and women aged 20-24 and 25-29, respectively. Figure A.3 shows the age of first marriage by gender.

# Appendix B Data appendix

## A. Dependent variables

Data on the number of births, live births, fetal deaths, child deaths and people are from *Nihonteikoku jonkodotai tokei* (Vital Statistics of Empire Japan; VSEJ, 1922-1931 editions), *Nihon jinkodotai tokei* (Vital Statistics of Japan; VSJ, 1932-1943 editions), *Jinkodotai tokei* (Vital Statistics; VS, 1946-1970 editions). These statistical documents are published by Statistical Bureau of the Cabinet (1926a-1932a), Statistical Bureau of the Cabinet (1934a-1945a), Department of Health Statistics, Ministry of Welfare (1949a-1949a), Department of Statistics and Investigation, Welfare Ministry's Secretariat (1949a-1949a), Devision of Health and Welfare Statistics, Welfare Ministry's Secretariat (1950a-1961a), Devision of Health and Welfare Statistics, Health and Welfare Ministry's Secretariat (1962a-1963a), and Health and Welfare Statistics Division, Minister's Secretariat, Ministry of Health and Welfare (1964a-1972a). Data on the number of married women and number of women aged 15–44 are from *Kokuseichosa hokoku* (Population Censuses) conducted between 1920 and 1970 spaced at 5-year intervals, except for 1945. These final reports of the Population Censuses were published by Statistics Bureau of the Cabinet (1929, 1935, 1962)and Bureau of Statistics, Office of the Prime Minister (1954, 1959, 1964, 1967, 1973).Data on height of children at age 6 in prewar Japan (data for 1929–1936) are from *Sintaikensa tōkei* published by the Physical Education Bureau, Secretariat of Education in 1931, 1937, and 1938. Data on height of children in postwar period (data for 1948–1970) are from *Gakkōhoken tōkeichōsa* published by the Ministry of Education. Original documents are publicly available at the portal sited for Japanese Government Statistics https://www.e-stat.go.jp/stat-search/files?page=1&toukei=00400002&tstat=000001011648. Since the physical examinations were conducted in April of each year for all primary schools in Japan from the early 20th century, our sample shares near entire child population. Random sampling methods for the population have been used for the postwar period. We have linearly interpolated the missing observations for the years between 1952 and 1954, and 1970. These imputations could be reasonable because child height had exhibited clear secular linear increasing trends in all prefectures and thus, the linear interpolations would not disturb the original trends in height. For finer details on these Japanese physical examination statistics, see Ogasawara (2017) and Schneider and Ogasawara (2018).

## B. Wartime losses of males

The losses of males relative to females during the war is defined as the sex ratio of people aged 15-59 in 1947 minus the sex ratio of people aged 15-59 in 1935, where the sex ratio is the number of males divided by the number of females. The data on the number of people aged 15-59 in all prefectures in 1935 are from *Showa jyunen, Kokuseichosa hokoku daiikkan, zenkoku-hen* (Population Census of 1935 vol.1, prefecture part) published by Cabinet Bureau of Statistics (1939).The data on the number of people aged 15-59 in all prefectures in 1947 are from *Showa nijyugonen, Kokuseichosa hokoku daihachikan, saisyu hokoku* (Population Census of 1955 vol.8, final report) published by Bureau of Statistics, Office of the Prime Minister (1955).The number of deaths from the air attacks (including the atomic bombs) in Japan and the number of people in 1944 are from the official reports published by the Headquarters for Economic Stabilization in 1949.

As described in the main text, the sex ratio recovered dramatically by 0.13, from 0.79 in 1945 to 0.92 in 1947. This considerable change within a relatively short time was undoubtedly caused by repatriated soldiers. Both the 3rd Census and the Extraordinary Population Census (EPC) reported that the number of males aged 15–59 increased by 3,787,242, from 17,832,427 in November 1945 (three months after the end of the war) to 21,619,669 in October 1947, during which time, the number of females increased by 1,424,327, from 21,630,062 to 23,054,389. The final report of the EPC noted that, within 17 months (May 1, 1946, to the end of September 1947), approximately 3,149,000 people had been repatriated to Japan, whereas approximately 223,000 people had left Japan. The natural increase during the same period was reported to be 1,677,000 (3,430,000 live births minus 1,753,000 deaths). Thus, the total increase in the population was 4,603,000 (i.e., 3,149,000 - 223,000 + 1,677,000; Statistics Bureau of the Prime Minister's Office 1948, p. 1).

## C. Control variables

Data on the number of workers in manufacturing industry and the number of labor force are from the Population Censuses conducted between 1920 and 1970 spaced at 5-year intervals except for 1940 and 1945. There final reports of the Population Censuses were published by Statistics Bureau of the Cabinet (1929, 1935, 1962)and Bureau of Statistics, Office of the Prime Minister (1954, 1959, 1964, 1967, 1973).For non-census years, we linearly interpolate this variable. Data on the wage rates from 1925 to 1957 are from the *Chokikeizai tokei* (Long-Term Economic Statistics, vol.2). We collected the time series of average daily wage earnings of manufacturing (Series B) form the table 26 in Umemura et. al, (1988, p. 246). Data on the wage rates from 1958 to 1970 are from the *Chinginkozo kihontokei* (Basic Survey on Wage Structure; BSWS). We collected the time series of regular earnings of the contractual cash earnings in enterprises with 10 or more regular employees in the manufacturing. To convert the monthly earnings into daily wage rates, the regular earnings in the BSWS are divided by 30.4 (i.e., 365 days/12 months). The data are publicly available and can be downloaded from http://www.stat.go.jp/data/chouki/zuhyou/19-37-a.xls. These wage rates are deflated by using Consumer Price Index (1934–1936=1) reported in Bank of Japan (1986, p. 436–438). Data on the meteorological variables, such as monthly average of the annual temperature and monthly average of annual precipitation are downloaded from the database of the Japan Meteorological Agency. Although the meteorological observation stations are located in each city in most cases, we replicate some missing data on the observations at the nearest meteorological observing station. The data are publicly available and can be downloaded from http://www.data.jma.go.jp/gmd/risk/obsdl/index.php.

### D. Time–series data

Data on the number of people by gender and by age groups used in Figure 1 are from the database of Statistics Bureau, Ministry of Internal Affairs and Communications (http://www.e-stat.go.jp/SG1/estat/List.do?bid=000000090004&cycode=0).

## Appendix C Theory appendix

The comparative statics effects are calculated by totally differentiating the following equations:

$$\begin{aligned} n^* - g(\theta, w^f, w^m) &= 0, \\ q^* - h(\theta, w^f, b) &= 0, \\ \theta^* - l(w^f, w^m, \sigma) &= 0. \end{aligned}$$

Note that the relation between $n, q$ and $\theta$ are

$$\begin{aligned} \frac{\partial g}{\partial \theta} &= \frac{(\varphi_m - \varphi_f)}{1+\phi} \frac{\left(w^f + w^m\right)}{w^f t} < 0 \\ \frac{\partial h}{\partial \theta} &= \frac{\phi}{\{\phi - [\theta \varphi_f + (1-\theta)\, \varphi_m]\}^2} \frac{w^f t}{b} > 0. \end{aligned}$$

Differentiating the endogenous variables $(g, h, l)$ with respect to the exogenous variable provides with the their partial effects on endogenous variables as

$$\frac{\partial g}{\partial w^m} = \frac{\{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]\}}{(1+\phi)\,w^f t} > 0,$$
$$\frac{\partial g}{\partial w^f} = -\frac{\{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]\}}{1+\phi}\frac{w^m}{(w^f)^2\,t},$$
$$\frac{\partial g}{\partial b} = 0,$$

and

$$\frac{\partial h}{\partial w^m} = 0,$$
$$\frac{\partial h}{\partial w^f} = \frac{[\theta\varphi_f + (1-\theta)\,\varphi_m]}{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]}\frac{t}{b} > 0,$$
$$\frac{\partial h}{\partial b} = -\frac{[\theta\varphi_f + (1-\theta)\,\varphi_m]}{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]}\frac{w^f t}{b^2} < 0.$$

Total differentiation of $(n, q, \theta)$ gives the matrix system as:

$$\begin{bmatrix} 1 & 0 & -\frac{\partial g}{\partial \theta} \\ 0 & 1 & -\frac{\partial h}{\partial \theta} \\ 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} dn^* \\ dq^* \\ d\theta^* \end{pmatrix}$$
$$= \begin{bmatrix} \frac{\partial g}{\partial w^m} \\ 0 \\ \frac{\partial \theta}{\partial w^m} \end{bmatrix} dw^m + \begin{bmatrix} \frac{\partial g}{\partial w^f} \\ \frac{\partial h}{\partial w^f} \\ \frac{\partial \theta}{\partial w^f} \end{bmatrix} dw^f + \begin{bmatrix} 0 \\ \frac{\partial h}{\partial b} \\ 0 \end{bmatrix} db + \begin{bmatrix} 0 \\ 0 \\ \frac{\partial l}{\partial \sigma} \end{bmatrix} d\sigma$$

where the denominator, $\Delta \equiv 1 > 0$.

Solving the matrix system with the results of partial effects, we have [28]

[28] Here, we conduct the comparative analysis of endogenous variables with respect to the price of quality, considering robustness check with the variations in the coverage of doctors.

$$
\begin{aligned}
\frac{dn^*}{dw^m} &= \left(\frac{\partial g}{\partial w^m} + \frac{\partial g}{\partial \theta}\frac{\partial l}{\partial w^m}\right)\Delta^{-1} \\
&= \frac{1}{(1+\phi)\,w^f t}\left[\{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]\} + (\varphi_m - \varphi_f)\left(w^f + w^m\right)\frac{\partial l}{\partial w^m}\right] > 0, \\
\frac{dn^*}{dw^f} &= \left(\frac{\partial g}{\partial w^f} + \frac{\partial g}{\partial \theta}\frac{\partial l}{\partial w^f}\right)\Delta^{-1}, \\
&= \frac{1}{(1+\phi)\,w^f t}\left[-\frac{\{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]\}\,w^m}{w^f} + (\varphi_m - \varphi_f)\left(w^f + w^m\right)\frac{\partial l}{\partial w^f}\right] < 0 \\
\frac{dn^*}{db} &= 0, \\
\frac{dn^*}{d\sigma} &= \frac{\partial g}{\partial \theta}\frac{\partial l}{\partial \sigma}\Delta^{-1} = \frac{(\varphi_m - \varphi_f)\left(w^f + w^m\right)}{(1+\phi)\,w^f t}\frac{\partial l}{\partial \sigma},
\end{aligned}
$$

and

$$
\begin{aligned}
\frac{dq^*}{dw^m} &= \left(\frac{\partial h}{\partial \theta}\frac{\partial l}{\partial w^m}\right)\Delta^{-1}, \\
&= \frac{\phi}{\phi - [\theta\varphi_f + (1-\theta)\varphi_m]^2}\frac{w^f t}{b}\frac{\partial l}{\partial w^m} < 0 \\
\frac{dq^*}{dw^f} &= \left(\frac{\partial h}{\partial w^f} + \frac{\partial h}{\partial \theta}\frac{\partial l}{\partial w^f}\right)\Delta^{-1}, \\
&= \frac{1}{\phi - [\theta\varphi_f + (1-\theta)\varphi_m]}\frac{t}{b}\left\{[\theta\varphi_f + (1-\theta)\varphi_m] + \frac{w^f\phi}{\phi - [\theta\varphi_f + (1-\theta)\varphi_m]}\frac{\partial l}{\partial w^f}\right\} > 0 \\
\frac{dq^*}{db} &= \left(\frac{[\theta\varphi_f + (1-\theta)\,\varphi_m]}{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]}\frac{w^f t}{b^2}\right) < 0, \\
\frac{dq^*}{d\sigma} &= \left(\frac{\partial h}{\partial \theta}\frac{\partial l}{\partial \sigma}\right)\Delta^{-1} \\
&= \frac{\phi}{\phi - [\theta\varphi_f + (1-\theta)\,\varphi_m]^2}\frac{w^f t}{b}\frac{\partial l}{\partial \sigma}
\end{aligned}
$$

# Appendix D Empirical analysis appendix

## D.1 Results for panel unit root tests

The results of Fisher-type panel unit-root tests based on augmented Dickey-Fuller (ADF) tests are reported in Table D.1. Fisher-type unit-root tests are used because of the finite number of panels of our sample (Choi 2001). The null hypothesis is that all the panels contain unit roots, whereas the alternative hypothesis is that at least one panel is stationary. In all specifications, the process under null hypothesis is assumed to be a random walk with drift. The demeaned data are used to deal with the effect of cross-sectional dependence.

Table D.1: Results for unit root tests for fertility and child death rates

| | Dependent variables | | | | | |
|---|---|---|---|---|---|---|
| Test statistics | General fertility rate | Child death rate | Marital fertility rate | Crude birth rate | Boys' height at age 6 | Girls' height at age 6 |
| $P$-statistic $p$-value | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $Z$-statistic $p$-value | 0.0517 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $L^*$-statistic $p$-value | 0.0465 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $P_m$-statistic $p$-value | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Number of prefectures | 46 | 46 | 46 | 46 | 46 | 46 |
| Number of periods | 35 | 33 | 33 | 33 | 31 | 31 |

Notes: The results of Fisher-type panel unit-root tests based on augmented Dickey-Fuller (ADF) tests are reported in this table. The null hypothesis is that all the panels contain unit roots, whereas the alternative hypothesis is that at least one panel is stationary. The process under null hypothesis is assumed to be a random walk with drift. The number of lagged differences in the ADF regression equation is set as one. The results presented herein are not affected by the number of lagged differences.

## D.2 Results for the maternal fertility rate and crude birth rate

To test the sensitivity to variable definition, this subsection presents additional results from the specification using the marital fertility and crude birth rates. The former is defined as the number of live births per 1,000 estimated number of married women. Since the precise number is recorded only in the census years, we linearly interoperated the number of married women. The mean, standard deviation, minimum, and maximum of the marital fertility rate are 119.5, 45.28, 39.43, and 227.51, respectively. The crude birth rate is defined as the number of live births per 1,000 people. The mean, standard deviation, minimum, and maximum of the crude birth rate are 24.64, 8.15, 9.58, and 45.89, respectively.

Columns (1)–(2) in Table D.2 shows the estimation results for the marital fertility rate. The parsimonious specification reported in column (1) includes prefecture fixed effects and year fixed effects only, without additional controls. Column (2) reports estimates for our baseline specification. We include controls for both female and male wage rates in manufacturing industry interacted with the share of both females and males in manufacturing, and the share of manufacturing workers interacted with the year fixed effects in this specification. As shown, the estimated coefficients on the interaction term are negative and statistically significant in both specifications. Our baseline specification reported in column (2) shows the estimated coefficient to be 119.408. This result implies

Table D.2: Effect of the women's bargaining power on the marital fertility rate and crude birth rate, by wartime losses of males

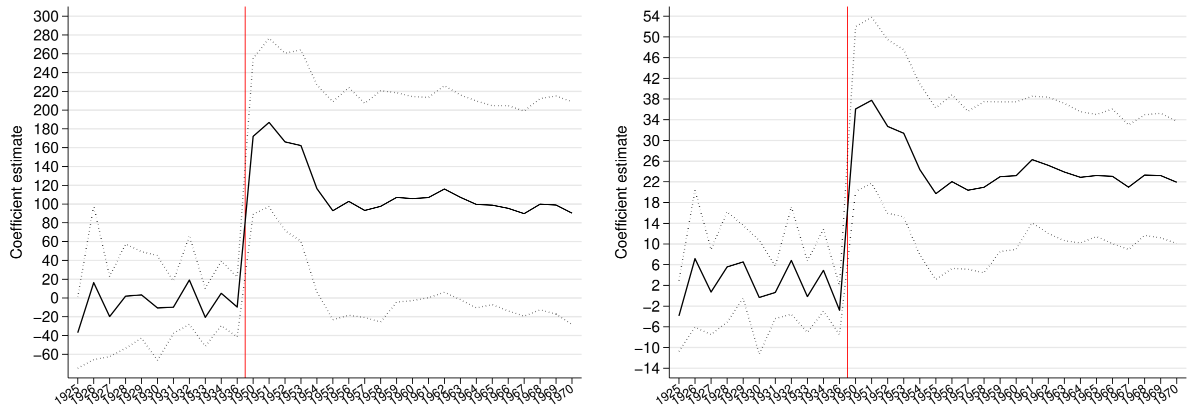
| | Marital fertility rate | | Crude birth rate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Change × Postwar dummy | 185.396* | 119.408** | 36.511** | 22.874*** |
| | (97.593) | (58.299) | (15.560) | (8.141) |
| Baseline control variables | No | Yes | No | Yes |
| Prefecture and year fixed effects | Yes | Yes | Yes | Yes |
| $R$-squared | 0.9331 | 0.9727 | 0.9282 | 0.9746 |
| Number of observations | 1518 | 1518 | 1610 | 1610 |

Notes: The dependent variable used in columns (1)–(2) is the number of live births per 1,000 married women. The dependent variable used in columns (3)–(4) is the number of live births per 1,000 people. The number of observations in columns (3)–(4) is 1610 because the data on the crude birth rate in postwar period can be obtained from 1948. The baseline control variables include the share of females in manufacturing (%) interacted with female wage rates, the share of males in manufacturing (%) interacted with male wage rates, and the share of manufacturing workers (%) interacted with the year fixed effects. *Postwar dummy* takes a value of "one" for 1950–1970 and "zero" otherwise. ***, ** and, * represent statistical significance at the 1% , 5%, and 10% level, respectively. Standard errors are clustered at the prefecture-level. Regressions in columns (1)–(2) are weighted by the average number of married females . Regressions in columns (3)–(4) are weighted by the average number of people.

that approximately a 20 percentage point increase in the wartime losses of males relative to females increased the maternal fertility rate by 3.58 (0.03 × 119.408) per mille. In columns (3)–(4), we used the crude birth rate because the data on the rate can be obtained from 1948, which enable us to include a few years around the end of 1940s. Column (3) includes prefecture fixed effects and year fixed effects only, while column (4) includes the baseline controls as in column (2). Clearly, the estimates are positive and statistically significant in both cases. The estimate in column (4) implies that approximately a 20 percentage point increase in the wartime losses of males relative to females increased the crude birth rate by roughly 0.7 (0.03 × 22.874) per mille.

Figure D.1a and D.1b illustrate the estimated vector of $\delta_j$s of equation (2) for the marital fertility rate and crude birth rate, respectively. Similar to the case in the general fertility rate (Figure 3), the estimated coefficients are larger in magnitude in the years after the war, whereas the estimated coefficients stay around zero in the years before the war.

To access the magnitude of our baseline estimates, we calculate the counterfactual fertility rate in 1970 for each prefecture if the postwar reform had not been conducted as we conducted in Section 4.2. The mean of the maternal fertility rate in our sample prefectures decreased by 77.6 per mille, from 149.39 in 1950 to 71.81 in 1970. By contrast, the counterfactual value of the marital ferility rate in 1970 is calculated as the summation of counterfactual values of each prefecture, which are computed as the observed maternal fertility rate in 1970 minus the baseline estimate reported in Column (2) in Table D.2




(a) Marital fertility rate

(b) Crude birth rate

Figure D.1: Marital fertility and crude birth rates in high male loss prefectures relative to low male loss prefectures, before and after WWII

Notes: The solid and dotted lines show the estimated coefficients and their 90 percent confidence intervals from a regression of the marital fertility or crude birth rates at the prefecture-year level on the changes in the sex ratio between 1935 and 1947, interacted with the year fixed effects. 1935 is set as a reference year. The control variables in the regression are the same variables used in columns (2) and (4) in Table D.2. Both the prefecture and the year fixed effects are included. Standard errors are clustered at the prefecture level. Regression is weighted by the average number of people in each prefecture.

multiplied by the wartime losses of male related to female, i.e., $\sum_{i=1}^{46}(Fertility_{i,1970} + 119.408 \times Changes_i)/46$. This simple calculation suggests that the counterfactual maternal fertility rate in 1970 would have been 62.34, implying the decrease in the maternal fertility rate would have been 87.05 (149.39−62.34). Thus, the decline in the maternal fertility rate might have been 112.2% (87.05/77.6) of the actual decline in the maternal fertility rate if the wartime loss of males had not been conducted. In other wards, our estimate claims that roughly 12% of the total increase in the maternal fertility rate between 1948–1970 was caused by the changes in the marriage market.

Similar calculation can be applied for the crude birth rate. The mean of the crude birth rate decreased by 16.51 per mille, from 33.77 in 1948 to 17.26 in 1970. The counterfactual value of the crude birth rate in 1970 is calculated as the sum of counterfactual values of each prefecture, which are computed as the observed crude birth rate in 1970 minus the baseline estimate reported in Column (4) of Table D.2 multiplied by the wartime losses of males relative to females, i.e., $\sum_{i=1}^{46}(Fertility_{i,1970} + 22.874 \times Changes_i)/46$. The counterfactual rate in 1970 would have been 15.45, implying that the decrease in the crude birth rate would have been 18.32 (33.77 − 15.45). Thus, the decline in the crude birth rate may have been 111% (18.32/16.51) of the actual decline in the crude birth rate if the wartime loss of males had not occurred. This implies that our estimate that roughly 11% of the total increase in the crude birth rate between 1948–1970 was caused by the changes in the marriage market.

These estimated figures are consistent with the figure for the general fertility rate (see Subsection 4.2). The above finding implies our assumption is plausible and finally confirms the fact that the birth controls in which conducted within the households had caused the decline in the fertility rate in postwar Japan.

## D.3 Sensitivity checks using alternative specifications

In the baseline specification, we control for the factors, which might affect the crude birth and child death rate, such as the degree of industrialization, standards of living, and opportunity cost for having children. Time–invariant determinants of the prefecture–specific marriage custom, birth customs and geographical features that could affect the standards of hygiene, are controlled for by including prefecture fixed effects. Unobserved macroeconomic shocks and the overall trends in the fertility and mortality are controlled for by year fixed effects.

Table D.3: Summary statistics for additional control variables

| | Observations | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Working-age population, log-transformed | 1518 | 13.48 | 0.63 | 12.24 | 15.78 |
| Doctors per 100 people, percentage points | 1518 | 0.09 | 0.03 | 0.02 | 0.22 |
| Average monthly temperature, Celsius | 1518 | 14.03 | 2.03 | 6.44 | 17.96 |
| Average monthly precipitation, millimeters | 1518 | 138.00 | 41.77 | 58.38 | 319.39 |

Notes: Observations are at the prefecture-year level. 46 prefectures and 1925-1970 periods (except for 1937-1947 periods) are included in total. Sources: See Online Appendix B.

In this subsection, we further add a few controls variables that might have potentially correlated with the fertility rate and changes in sex ratio. These variables are the number of people aged 20-59 and coverage of medical doctors. The former variable is included to control for the compensating responses against the loss of working-age population in the society, whereas the latter one controls for the public health and potential wealth levels. Controlling the number of doctors may be also useful to consider the situation that the number of doctors related to the male scarcity in the region, followed by the worsen quality of children in the region with severe male scarcity.

In addition to these, the meteorological heterogeneity such as the variation in temperature and precipitation across prefectures might have affected the outcome variables via the livability and the industrial structure via the agricultural suitabilities directly or indirectly. Therefore, we further control for meteorological characteristics of the prefectures using the monthly average of annual temperature and the monthly average of annual precipitation, in addition to the control for the fraction of manufacturing industry and the wage rates. The summary statistics of these variables are listed in Table D.3.

Table D.4: Robustness to controlling for additional factors

| | General fertility rate | | Child death rate | | Boys' height at age 6 | | Girls' height at age 6 | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Changes × Postwar dummy | 105.080** | 104.223** | 27.759*** | 27.953*** | -3.273*** | -3.268*** | -2.633* | -2.642* |
| | (46.050) | (46.092) | (10.058) | (9.999) | (0.934) | (1.935) | (1.373) | (1.373) |
| Baseline control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Working-age population | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Coverage of doctors | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Average temperature | No | Yes | No | Yes | No | Yes | No | Yes |
| Average precipitation | No | Yes | No | Yes | No | Yes | No | Yes |
| Prefecture and year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $F$-statistic $p$-value on joint significance of additional controls | 0.401 | 0.698 | 0.123 | 0.076 | 0.566 | 0.671 | 0.695 | 0.924 |
| $R$-squared | 0.9784 | 0.9784 | 0.9681 | 0.9682 | 0.9835 | 0.9800 | 0.9835 | 0.9835 |
| Number of observations | 1518 | 1518 | 1518 | 1518 | 1334 | 1334 | 1334 | 1334 |

Notes: The baseline control variables include the share of females in manufacturing (%) interacted with female wage rates, the share of males in manufacturing (%) interacted with male wage rates, and the share of manufacturing workers (%) interacted with the year fixed effects. ***, ** and, * represent statistical significance at the 1% , 5%, and 10% level, respectively. Standard errors are clustered at the prefecture level.

The estimates are reported in Table D.4. Columns (1), (3), (5), and (7) report the result from specification that includes baseline controls, working-age population, and coverage of doctors. Columns (2), (4), (6), and (8) also include both average monthly temperature and precipitation. The estimates are stable against inclusion of these variables. The estimated coefficients in Columns (2), (4), (6), and (8) are 104.223, 27.953, −3.268, and −2.642 respectively. These effects in magnitude are similar to those reported in Table 2. After all, the results of $F$-tests reported in Table D.4 show that these additional variables are not jointly significant in most cases, suggesting the validity of our baseline specification. We have also confirmed that the results for the marital fertility rate and crude birth rate (reported in Table D.2) are robust for including these additional variables (not reported).

## D.4 Falsification test

The changes in the sex ratio should have significant effected not before the war but after the war if the changes in the sex ratio had affected a large random components due to the losses of males during the war. In other words, if the coefficient on the interaction term between $Changes_i \times Post_t$ was estimated to be statistically significant, this key variable in our baseline specification may correlate with other factors, which might have affected the crude birth rate, child death rate, or children's height. To assess these possibilities, we then estimate the baseline specification for prewar period from 1925 to 1936.

The estimates are reported in Table D.5. The placebo treatment periods in Columns (1)–(2), (3)–(6), and (7)–(10) are the years from 1928–1936, 1931–1936, and 1934–1936, respectively. Note that our data on height of children are only available after 1929 (On-

Table D.5: Baseline estimates for alternative cutoff period: Falsification test

| | Placebo treatment periods | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1928–1936 | | 1931–1936 | | | | 1934–1936 | | | |
| | (1)GFR | (2)CDR | (3)GFR | (4)CDR | (5)Boys' height | (6)Girls' height | (7)GFR | (8)CDR | (9)Boys' height | (10)Girls' height |
| Changes × Postwar dummy | -2.282 | -9.846 | -11.496 | -3.928 | -1.130 | 2.457 | -13.124 | -2.102 | 1.398 | 1.254 |
| | (20.569) | (10.146) | (22.314) | (5.262) | (0.943) | (1.496) | (21.934) | (6.146) | (1.716) | (0.747) |
| Baseline control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Prefecture and year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R$-squared | 0.9819 | 0.7626 | 0.9819 | 0.7618 | 0.8381 | 0.8593 | 0.9819 | 0.7616 | 0.8385 | 0.8579 |
| Number of observations | 552 | 552 | 552 | 552 | 368 | 368 | 552 | 552 | 368 | 368 |

Note: The baseline control variables include the share of females in manufacturing (%) interacted with female wage rates, the share of males in manufacturing (%) interacted with male wage rates, and the share of manufacturing workers (%) interacted with the year fixed effects. Standard errors are clustered at the prefecture level. Regressions (1), (3), and (7) are weighted by the average number of women aged 15–44 in each prefecture. Regressions (2), (4), and (8) are weighted by the average number of children, excluding infants, in each prefecture. Regressions (5) and (9) ((6) and (8)) are weighted by the average number of males (females) in each prefecture.

line Appendix B). This means that, for example in Columns (1)–(2), we use the interaction term between the changes in the sex ratio and an indicator variable that equals one for the years from 1928 to 1936. The same is true for the estimates listed in Columns (3)–(6) and (7)–(10). The estimated coefficients do not differ significantly from zero, and those impacts are considerably weak in all specifications and are negligible. This result from placebo test confirms the evidence that our key explanatory variable, the changes in the sex ratio, had no significant effects on our dependent variables in the prewar periods. We have also confirmed that this argument also holds for both the marital fertility and crude birth rates (not reported).

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