The Baby Boom and World War II: A Macroeconomic Analysis*

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Abstract

We argue that one major cause of the U.S. postwar baby boom was the increased demand for female labor during World War II. We develop a quantitative dynamic general equilibrium model with endogenous fertility and female labor-force participation decisions. We use the model to assess the long-term implications of a one-time demand shock for female labor, such as the one experienced by American women during wartime mobilization. For the war generation, the shock leads to a persistent increase in female labor supply due to the accumulation of work experience. In contrast, younger women who turn adult after the war face increased labor-market competition, which impels them to exit the labor market and start having children earlier. In our calibrated model, this general-equilibrium effect generates a substantial baby boom followed by a baby bust, as well as patterns for age-specific labor-force participation and fertility rates that are consistent with U.S data.

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All the day long, whether rain or shine,
She's a part of the assembly line.
She's making history, working for victory,
Rosie the Riveter.[1]

1 Introduction

In the two decades following World War II the United States experienced a massive baby boom. The total fertility rate[2] increased from 2.3 in 1940 to a maximum of 3.8 in 1957 (see Figure 1). Similarly, the data on cohort fertility show an increase from a completed fertility rate[3] of 2.4 for women whose main childbearing period just preceded the baby boom (birth cohorts 1911–1915) to a rate of 3.2 for the women who had their children during the peak of the baby boom (birth cohorts 1931–1935; see Figure 2). The baby boom was followed by an equally rapid baby bust. The total fertility rate fell sharply throughout the 1960s, and was below 2.0 by 1973. The baby boom constituted a dramatic, if temporary, reversal of a century-long trend towards lower fertility rates. Understanding the causes of the baby boom is thus is a key challenge for demographic economics.

In this paper, we propose a novel explanation of the baby boom, based on the demand for female labor during World War II. As documented by Acemoglu, Autor, and Lyle (2004), the war induced a large positive shock to the demand for female labor. While men were fighting the war in Europe and Asia, millions of women were drawn into the labor force and replaced men in factories and offices.[4] The effect of the war on female employment was not only large, but also persistent: the women who worked during the war accumulated valuable labor-market experience, and consequently many of them continued to work after the war.

[1] "Rosie the Riveter," lyrics by Redd Evans and John Jacob Loeb, 1942.

[2] The total fertility rate in a given year is the sum of age-specific fertility rates over all ages. It can be interpreted as the total number of children an average woman will have over her lifetime if age-specific fertility rates stay constant over time.

[3] The completed fertility rate is the average lifetime number of children born to mothers of a specific cohort. Dynamic patterns of total and completed fertility rates can deviate if there are shifts in the timing of births across cohorts.

[4] The U.S. government actively campaigned for women to join the war effort. "Rosie the Riveter," a central character in the war-time campaign for female employment, has become a cultural icon and a symbol of women's expanding economic role.

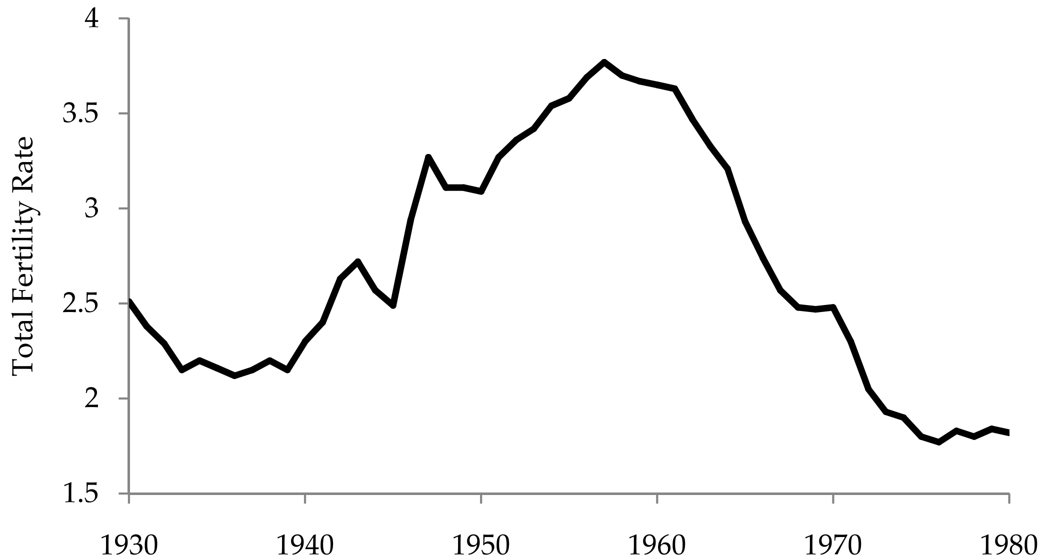

Figure 1: The Total Fertility Rate in the United States (Source: Chesnais 1992)

At first sight, it might seem that this additional supply of female labor should generate the opposite of a baby boom: women who work have less time to raise children and usually decide to have fewer of them. The key to our argument, however, is that the one-time demand shock for female labor had an *asymmetric* effect on younger and older women. The only women who stood to gain from additional labor market experience were those who were old enough to work during the war. For younger women who were still in school during the war the effect was negative: when they turned adult after the war and entered the labor market, they faced increased competition. In addition to the men who returned from the war, a large number of the experienced women of the war generation were still in the labor force. We argue that this led to less demand for inexperienced young women, who were crowded out of the labor market and chose to have more children instead. It is these younger women who account for the bulk of the baby boom.

Our explanation is consistent with the observed patterns of female labor-force participation before the war and during the baby boom. In the period leading up to the war, the vast majority of single women in their early 20s were working. In contrast, labor-force participation rates for married women were low. Hence, a typical woman would enter the labor force after leaving school, and then quit

Figure 2: The Completed Fertility Rate in the United States by Cohort (i.e., by Birth Year of Mother. Source: Jones and Tertilt 2006)

working (usually permanently) once she got married and started to have children. Figure 3 shows how the labor supply of young (ages 20–32) and older (ages 33–60) women evolved after the war. During the baby-boom period, the labor supply of older women increased sharply, whereas young women worked less. A substantial part of the drop of young female labor supply is due to a compositional shift from single to married women. It is not so much that young single women no longer worked, but rather that they married earlier, which (given the low average labor supply of married women) lowers the total amount of labor supplied by young women. Our theory generates the same patterns as a result of the wartime demand shock for female labor.

Our theory is also consistent with the observation that most of the baby boom is accounted for by young mothers. Figure 4 displays birth rates for different age groups of mothers throughout the baby-boom period. Both in absolute and relative terms, women aged 20–24 experienced the largest increase in fertility. For mothers aged 25–29, the increase in fertility is more than one-third smaller than in the younger group, and among even older mothers the baby boom is either small or nonexistent. In our theory, fertility increases because women exit the labor force and start having children earlier, which implies that, as observed in

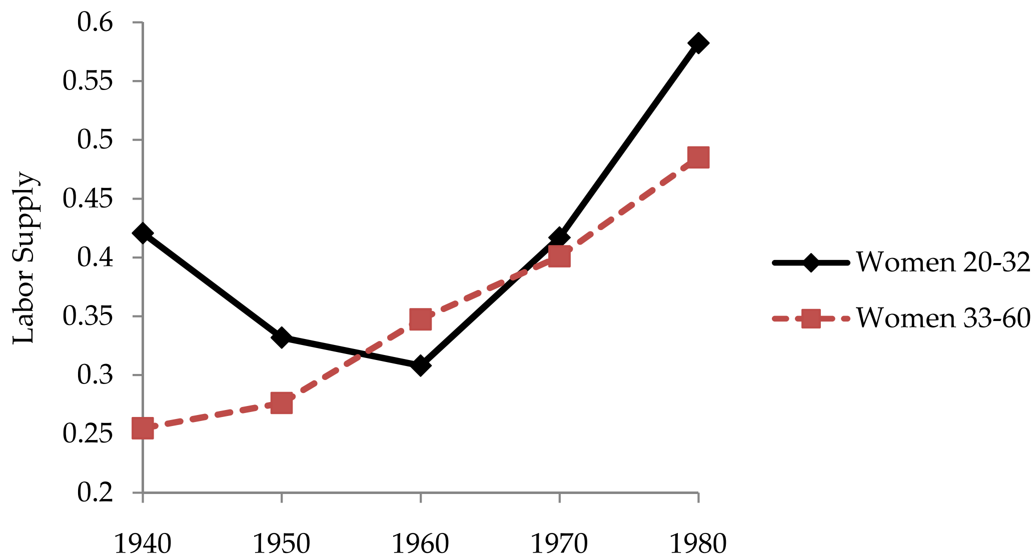

Figure 3: Labor Supply by Young (20–32) and Old (33–60) Women in the United States relative to Men in the same Age Group (includes women of all races and marital statuses, see Appendix A.2 for details)

the data, the increase in fertility takes place at the beginning of the child-bearing period.

To examine the plausibility of our mechanism in more detail, we develop a dynamic general-equilibrium model that focuses on married couples' life-cycle decisions on fertility and female labor-force participation. In the model, all women start out working when young, but ultimately quit the labor force in order to have children. Since the fecund period is limited, having more children requires leaving the labor market earlier. Due to the time cost of having children and an adjustment cost of reentering the labor market, only some women resume work after having children. Since fertility and labor-force participation decisions are discrete, the model incorporates preference heterogeneity in order to generate heterogeneous behavior in these dimensions. At the aggregate level, the model features a standard production technology with limited substitutability of male and female labor. We calibrate the model to U.S. data, and then shock the model's balanced growth path with a World War II shock, represented as a one-time reduction in male labor supply and an increase in demand for female labor.

We find that the model does an excellent job at reproducing the main qualitative

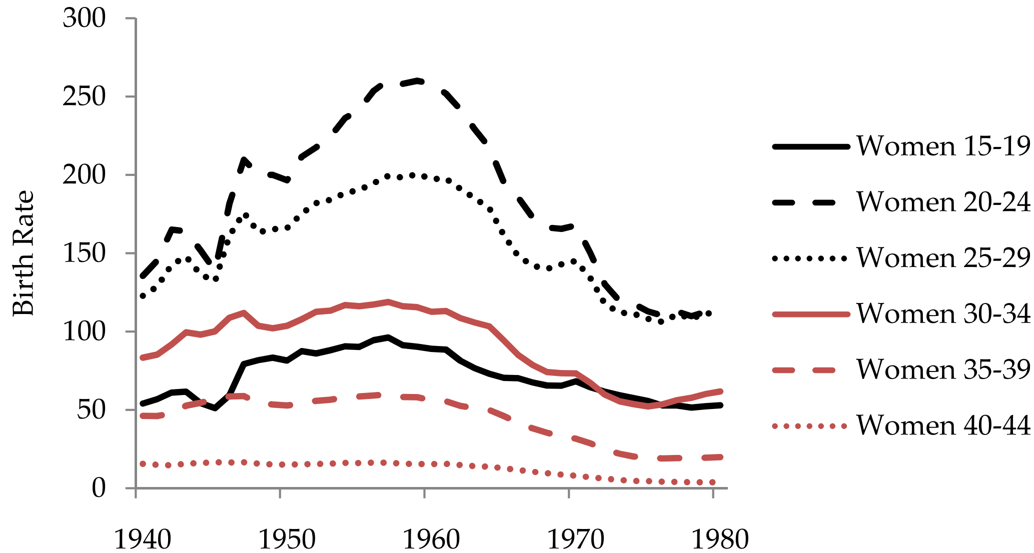

Figure 4: Number of Births per 1,000 Women in Different Age Groups in the United States (Source: Vital Statistics of the United States, see Appendix A.1 for Details)

features of the U.S. baby boom: the patterns for fertility, the timing of births, female labor-force participation rates, and relative male and female wages are all consistent with empirical observations. The model does particularly well at reproducing the timing of the baby boom and baby bust. The baby boom reverses once the war generation of working women starts to retire from the labor market. This model implication results in a sharp reduction in fertility 15 to 20 years after the war shock, which closely matches the baby bust period of the 1960s.

Turning to quantitative implications, we find that in our baseline calibration the model can account for a major fraction of the increase in cohort fertility during the baby boom. However, the exact size of the rise in fertility depends on model parameters that are difficult to pin down empirically. A sensitivity analysis shows that there is a range of plausible outcomes for the size of the fertility effect. Nevertheless, as long as we constrain the model's predictions for variables other than fertility (in particular labor-force participation rates) to be consistent with empirical evidence, the increase in fertility is substantial.

Another way to assess the empirical relevance of the labor-market mechanism is to consider data on the baby boom in countries other than the United States.

Most industrialized countries experienced a baby boom after World War II, but only some of them also underwent a substantial mobilization of female labor during the war. Our theory predicts that countries with a larger wartime increase in the female labor force should also experience larger baby booms. The international data is consistent with this prediction. In particular, we compare the baby boom in countries that had a wartime experience similar to the United States (Allied countries that mobilized for the war but did not fight on their own soil, namely Australia, Canada, and New Zealand) with neutral countries that did not experience a large demand shock for female labor (Portugal, Spain, Sweden, and Switzerland). We find that the Allied countries experienced a large baby boom quite similar to the one in the United States, whereas the increase in fertility was much smaller in the neutral countries. We regard the larger baby boom in the Allied countries as a strong indication that our mechanism is relevant. At the same time, the fact that the neutral countries had baby booms at all also suggests that our mechanism cannot be the only explanation: some factor other than the dynamics of the female labor market must have also played a role.

The remainder of the paper is organized as follows. In the following section, we relate our work to the existing literature. The model economy is described in Section 3. In Section 4, we calibrate the model to the pre-war U.S. economy. The main results are presented in Section 5, where we discuss the model's implications for the effects of World War II. International evidence is discussed in Section 6. Section 7 concludes.

2 Related Literature

The perhaps most widely known explanation for the baby boom is Easterlin's (1961) relative income hypothesis.[5] Easterlin postulates that fertility decisions are

[5]Also well known is what might be termed the "catch-up fertility" hypothesis, i.e., the idea that fertility rates rose after the war because couples were making up for babies they were not able to have during the war. However, while this mechanism probably contributed to the spike in fertility in 1946 and 1947, the literature has long recognized that it cannot explain the main phase of the baby boom in the 1950s. As shown in Figure 4, most of the baby-boom mothers were too young to be married during the war. More importantly, the data on completed fertility show that women increased their lifetime fertility during the period, which would not be the case if the baby boom solely represented a shift in the timing of births from during to after the war (see Figure 2).

driven by the gap between couples' actual and expected material well-being. Applying this theory to the U.S. baby boom, Easterlin argues that people who grew up during the Great Depression had low material aspirations. Overwhelmed by the prosperity of the post-war years, they increased their demand for children. One of the problems with this explanation is that the timing is not quite right.[6] As we documented above, most of the baby boom was accounted for by young mothers aged 20–24. During the baby boom fertility peaked in 1957. Mothers who were 20–24 years old in 1957 were born between 1933 and 1937, and spent much of their childhood during the prosperous post-war period.[7]

Greenwood, Seshadri, and Vandenbroucke (2005) propose an alternative theory based on improvements in household technology. They argue that the widespread diffusion of appliances such as refrigerators, washers, dishwashers, and electric stoves enabled women to run their households in much less time than before, which lowered the time cost of raising children. This theory is complementary to ours in the sense that in each case the focus is on the opportunity cost of having children, albeit from different ends: In Greenwood et al. the direct cost of having a child declines, while in our model it is the opportunity cost of time (i.e., young women's wage) that goes down. We believe both these aspects to be relevant. One observation that supports the relative importance of our theory is that most of the baby boom is accounted for by young women. If the baby boom was exclusively due to a general lowering of the cost of having children, we would expect to see a substantial increase in fertility at all ages. The data suggest that there was a decline in a component of the opportunity cost that applies only to young mothers. This is exactly what happens in our model: the key margin is the opportunity cost of time at the transition from working to motherhood, which is operative only at the beginning of the childbearing period. A second

[6] This was pointed out by Greenwood, Seshadri, and Vandenbroucke (2005).

[7] A related possibility is that the state of the economy has an immediate impact on fertility, rather than working with a lag of one generation as in Easterlin's hypothesis. Along these lines, Jones and Schoonbroodt (2007) use a quantitative dynastic fertility choice model to assess the extent to which economic shocks (such as the Great Depression and World War II) affect fertility behavior. They find that the Great Depression can account for much of the trough in fertility in the 1930s. However, they also show that in their model (which does not feature the female labor-market setup that is essential for our theory) World War II and the subsequent economic expansion do not lead to a sizeable baby boom.

advantage of our theory is that it does better at accounting for the baby bust, i.e., the sharp decline of fertility in the 1960s.

Our work is also related to the account of the baby boom provided by Butz and Ward (1979). Butz and Ward provide a static statistical model of fertility decisions and argue that, empirically, fertility reacts to the relative wages of men and women. In particular, they argue that during the baby boom period relative wages of women were low, which lowered the opportunity cost of having children and increased fertility. Our theory shares with Butz and Ward (1979) the emphasis on relative female wages as a key determinant of the opportunity cost of having children. An important difference is that in our theory the earnings potentials of young and old women have opposite implications for fertility choices, whereas Butz and Ward do not make this distinction.[8] Moreover, we provide a general-equilibrium model in which relative male and female wages are endogenously determined, which is essential for our main argument, namely the link between the demand for female labor during World War II and the subsequent baby boom.

The structure of our model of fertility choice builds on Galor and Weil (1996). In particular, Galor and Weil also provide a general-equilibrium model where couples jointly decide on fertility and labor supply and where the opportunity cost of children is determined by the relative female wage. However, Galor and Weil focus on the long-run trend of declining fertility and do not discuss the baby boom. In addition, unlike Galor and Weil we develop a life-cycle model where the interaction between successive cohorts is key for the economic mechanism. Our emphasis on the timing of fertility is shared with Caucutt, Guner, and Knowles (2002), who use an integrated model of the marriage market, female labor supply, and fertility to explain patterns of fertility timing in the United States. Life-cycle models of fertility and female labor-force participation have also been developed and estimated in the labor literature (see for example Moffit 1984 and Eckstein and Wolpin 1989). One feature that is important both in this literature and our theory is the endogenous accumulation of work experience. However, the papers in the labor literature focus on the estimation of partial-equilibrium choice

[8]One indication that this matters is the finding in Macunovich (1995) that the original Butz and Ward results cannot be replicated with more recent updated data.

models, and therefore lack the general equilibrium aspect that is essential for our mechanism.

We also build on the literature that analyzes the role of World War II in explaining the rise in female employment. Goldin (1991) reports that 25 percent of the working women in the age group 27–51 in 1951 were women who did not work in December 1941 but worked in March 1944 and January 1951, and are therefore likely to have entered the labor force due to the war. Among the women who did not work in December 1941 but worked in March 1944, 65 percent were still working in 1951. Given that we match the post-war increase in the labor-force participation of older married women to data, our analysis is consistent with these findings.[9]

Our mechanism relies on the assumption that the increase in female employment after World War II affected wages. More specifically, in our model fertility decisions are largely driven by the wages of young women relative to those of men. An key question from the perspective of our theory is therefore how substitutable male and female labor were in the decades following the war. Acemoglu, Autor, and Lyle (2004) provide a study that is ideally suited to answer this question. The authors show that U.S. states with a greater mobilization of men during the war (and thus a higher demand for female labor) also had a larger postwar increase in female employment, whereas relative female wages declined relative to states with lower mobilization rates. Thus, their results confirm the link between the rise of female employment in World War II and increased subsequent competition in the female labor market that is an essential ingredient of our mechanism. Moreover, Acemoglu, Autor, and Lyle provide estimates of the elasticity of substitution between male and female labor during the baby boom period, which we use in the calibration of our model in Section 4 below.

An important question is whether the war may have had an impact on female employment that went beyond the impact on individual employment histories that Goldin (1991) focuses on. An argument of this kind is presented by Fernández, Fogli, and Olivetti (2004), who argue that one factor that held back female em-

[9]See also Clark and Summers (1982) for additional evidence supporting an important role of World War II for the rise in female employment.

ployment is husbands' prejudice against working wives. The extent of this prejudice, in turn, depends on whether a husband's own mother was working. Given this mechanism, the demand for female labor during the war increased married women's labor-force participation one generation later, when the sons of the working mothers of the war got married. More generally, it has been argued that simply observing more married women work will tend to reduce prejudice against and misinformation about working women. Along these lines, Fernández (2007) and Fogli and Veldkamp (2007) have developed formal learning models that give rise to the S-shape dynamics in female labor-force participation that characterize the data.[10] Accounting for mechanisms of this kind would lead to an even higher estimate of the impact of World War II on female employment. We return to this point in Section 5.4 below.

A number of recent studies have used quantitative macroeconomic models to examine the sources of recent (i.e., post baby boom) changes in relative female earnings and female labor-force participation. Within this literature, Olivetti (2006) also emphasizes endogenous work experience and argues that an increase in the returns to experience are a major reason behind the increase in female participation since the 1970s. In contrast, Attanasio, Low, and Sanchez-Marcos (2004) analyze the labor-force participation choices of three cohorts of American women (those born in the 1930s, 1940s, and 1950s), and conclude that a decline in the relative cost of children is the most likely explanation for participation changes. Yet other explanations for the rise in female employment are preferred by Greenwood, Seshadri, and Yorukoglu (2004) and Albanesi and Olivetti (2007) (improvements in household and medical technology) and Jones, Manuelli, and McGrattan (2003) (an exogenous narrowing of the gender gap). While the focus of these studies is different from ours, there are a number of similarities in terms of modeling the female labor market, such as accounting for life-cycle choices and a role for endogenous experience. Recent related work on endogenous gender wage differentials includes Erosa, Fuster, and Restuccia (2002, 2005) and Albanesi and Olivetti (2006). As in our theory, in these studies the gender wage gap arises ultimately as a consequence of actual or potential childbirth.

[10] See also Hazan and Maoz (2002).

3 The Model Economy

At the aggregate level, our model is a version of the standard neoclassical growth model that underlies much of the applied literature in macroeconomics. We enrich this framework by modeling married couples' life-cycle decisions on fertility and female labor-force participation. Since fertility and labor-force participation decisions are discrete, the model incorporates preference heterogeneity so as to generate heterogeneous behavior in these dimensions. The production technology features limited substitutability of male and female labor, which implies that changes in the relative labor supply of men and women affect the gender wage gap.

3.1 Couples' Life-Cycle Choices of Fertility and Labor Supply

The model economy is populated by married couples who live for $T + 1$ adult periods, indexed from 0 to T. Men work continuously until model period R, after which they retire. Women can choose in every period whether or not to participate in the labor market. Working women also retire after period R. Apart from deciding on labor supply, the main decision facing our couples is the choice of their number of children. Parents raise their children for I periods, at which time the children turn adult. All decisions are taken jointly by husbands and wives. A couple turning adult in period t maximizes the utility function:

$$U_t = \sum_{j=0}^{T} \beta^j \left[\log(c_{t,j}) + \sigma_x \log(x_{t,j})\right] + \sigma_n \log(n_t).$$

Here $c_{t,j}$ is consumption at age j of a household who turned adult in period t, $x_{t,j}$ is female leisure, and n_t is the number of children. Male leisure does not appear in the utility function, as men are continuously employed until retirement and their leisure is therefore fixed. The flow budget constraint that a couple turning adult in period t faces in period $t + j$ is:

$$c_{t,j} + a_{t,j+1} = (1 + r_{t+j})a_{t,j} + w^m_{t+j} e^m_{t,j} + w^f_{t+j} e^f_{t,j} l_{t,j}.$$

Here $a_{t,j}$ are assets (savings), r_{t+j} is the interest rate in period $t+j$, w^m_{t+j} is the male wage, $e^m_{t,j}$ is male labor-market experience (i.e., labor supply in efficiency units), w^f_{t+j} is the female wage, $e^f_{t,j}$ is female labor-market experience, and $l_{t,j}$ is female labor supply, which can be either zero or one (male labor supply is always assumed to be one). People are born and die without assets ($a_{t,0} = a_{t,T+1} = 0$).

For $j < R$ (i.e., until retirement age), labor market experience evolves according to:

$$\begin{aligned} e^m_{t,j+1} =& (1+\eta_m)e^m_{t,j}, \\ e^f_{t,j+1} =& (1+\eta_f l_{t,j} - \nu(1-l_{t,j}))e^f_{t,j}, \end{aligned}$$

where η_m is the return to male experience, η_f is the return to female experience, and ν is the depreciation rate of labor market experience for a woman who is currently not working. We do not model depreciation of male experience since men are continuously employed. Initial experience is normalized to one for both sexes, $e^m_{t,0} = e^f_{t,0} = 1$. For $j > R$ we have $e^m_{t,j} = e^f_{t,j} = 0$, i.e., men and women are no longer productive once they reach retirement age.

For young women who haven't had children yet, leisure is given by:

$$x_{t,j} = h - l_{t,j} - z_{t,j}.$$

Here h is the time endowment, and the variable $z_{t,j} \in \{0, \bar{z}\}$ is an adjustment cost (in terms of time) that has to be paid when a woman reenters the labor force, i.e., switches from non-employment to employment. This cost captures the job search effort as well as any other costs, pecuniary or emotional, that are incurred when reentering the labor force. The cost has to be paid only once for a female employment spell.[11] We assume that women are already employed at the beginning of adulthood, so that the cost does not have to be paid for the initial employment spell. The general leisure constraint, which also includes the costs of having children, is given by:

$$x_{t,j} = h - \phi(n^y_{t,j})^\psi - \kappa\, b_{t,j} - l_{t,j} - z_{t,j}.$$

[11]More precisely, we have $z_{t,j} = \bar{z}$ if $l_{t,j} = 1$ and $l_{t,j-1} = 0$, and $z_{t,j} = 0$ otherwise.

Here $n^y_{t,j}$ is the number of young (i.e., non-adult) children who are still living with their parents, $\phi > 0$ and $\psi > 0$ are parameters governing the level and curvature of the cost of children, $b_{t,j} \in \{0, 1\}$ indicates whether a birth has taken place in period j, and $\kappa \geq 0$ is the additional time cost for the birth over and above the general time cost of children. Children live with their parents for I periods, after which they turn adult, form their own households, and are no longer costly to their parents. For simplicity, and realistically for the period, we assume that women who give birth do not work during the same period. Women can give birth only until age M, and only one birth per period is possible. Thus, for example, a woman planning to have three children must start giving birth at age $M - 2$. The total number of children is given by the total number of births:

$$n_t = \sum_{j=0}^{M} b_{t,j},$$

and the number of non-adult children in any period is given by:

$$n^y_{t,j} = \begin{cases} \sum_{k=\max\{0,j-(I-1)\}}^{\min\{j,M\}} b_{t,k} & \text{if} \quad j \leq M + I - 1, \\ 0 & \text{if} \quad j > M + I - 1. \end{cases}$$

The population is heterogeneous in terms of the appreciation of leisure, i.e., the parameter σ_x in the utility function varies across couples.[12] In particular, in any cohort the distribution of σ_x is governed by the distribution function $F(\sigma_x)$. The distribution of σ_x determines the average female labor force participation rate at different ages. In the model, it is optimal for women to have children as late as possible, i.e., women work initially and then have children until they reach age M. Subsequently, only women with a relatively low appreciation for leisure (i.e.,

[12]Our aim is to introduce heterogeneous behavior in terms of fertility and labor-force participation while keeping the model parsimonious. We therefore introduce preference heterogeneity only along the leisure dimension. Introducing heterogeneity in terms of the preference for children would be less effective, because conditional on the number of children all women would have identical preferences at the labor-leisure margin. In principle, heterogeneous behavior could also arise with homogeneous preferences, as long as couples are indifferent between all bundles that are chosen in equilibrium. However, such a model would have the unattractive feature that aggregates are infinitely elastic with respect to infinitesimal price changes.

a low disutility for work) return to the labor force.

3.2 The Aggregate Production Function and Market Clearing

The production technology is given by:

$$Y_t = A_t^{1-\alpha} K_t^{\alpha} \left(\theta (L_t^f)^{\rho} + (1-\theta)(L_t^m)^{\rho} \right)^{\frac{1-\alpha}{\rho}},$$

where A_t is productivity, K_t is the aggregate capital stock, L_t^f is female labor supply in efficiency units, and L_t^m is male labor supply in efficiency units. The aggregate capital stock depreciates at rate δ per period. The production function allows for limited substitutability between male and female labor, governed by the parameter ρ. Productivity increases at a constant rate γ every period:

$$A_{t+1} = (1+\gamma) A_t.$$

In the balanced growth path, the growth rate of output per capita will be equal to γ. The production technology is operated by perfectly competitive firms, so that all factors are paid their marginal products and profits are equal to zero in equilibrium.

Let P_t denote the size of cohort t (i.e., the number of couples who enter adulthood in t). The market-clearing condition for capital is given by:

$$K_t = \sum_{s=1}^{T} P_{t-s} \int_0^{\infty} a_{t-s,s} \, dF(\sigma_x),$$

that is, the capital stock is equal to the sum of the assets of all cohorts that are currently alive, where in the integral it is understood that assets $a_{t-s,s}$ are a function a household's leisure-preference parameter σ_x. Similarly, the market-clearing condition for male labor is given by:

$$L_t^m = \sum_{s=0}^{R} P_{t-s} \int_0^{\infty} e_{t-s,s}^m \, dF(\sigma_x),$$

and female labor supply satisfies:

$$L_t^f = \sum_{s=0}^{R} P_{t-s} \int_0^{\infty} e_{t-s,s}^f \, l_{t-s,s} \; dF(\sigma_x).$$

Finally, given that children turn adult at after spending I periods with their parents, the cohort sizes P_t evolve according to the law of motion:

$$P_{t+I} = \frac{1}{2} \sum_{s=0}^{M} P_{t-s} \int_0^{\infty} b_{t-s,s} \; dF(\sigma_x).$$

The factor $\frac{1}{2}$ enters the law of motion because fertility is measured in terms of individuals while cohort size is measured in terms of couples. More precisely, $b_{t-s,s}$ describes the number of births (zero or one) of a couple born in period $t-s$ at time t. Integrating over all these couples and multiplying by this cohort's size P_{t-s} gives the total number of children born in period t to parents from cohort $t-s$. Summing this over all cohorts who are in childbearing age in period t (i.e., those aged zero to M) yields the total number of children born in period t. Dividing by 2 results in the number of couples P_{t+I} turning adult I periods later.

3.3 Fertility and Female Labor Supply in the Balanced Growth Path

The model economy features a balanced growth path in which income per capita, wages, and consumption all grow at the rate of productivity growth γ, whereas fertility and female labor-force participation rates are constant. Before introducing the war shock, it is instructive to consider how fertility and female labor-force participation decisions are determined in our theory. In the calibrated version of the model (see Section 4 below), all women initially enter the labor force when turning adult, and then quit in order to have children. It turns out to be optimal to have children as late as possible, because then the initial earnings period can be extended and the time cost of having children can be delayed. Women therefore have children right up to the final fecund period M. A different way to put this is that the marginal child is the first one: women who want to have an additional child must leave the labor force one period earlier. What then determines whether a woman will have an additional child?

Consider, first, the case of a woman who does not anticipate reentering the labor force after having children. For such a woman, both the marginal utility of having another child and the disutility (in terms of reduced leisure) of raising the child are fixed numbers. The only variable part of the tradeoff is the opportunity cost of having to exit the labor force earlier, which depends on forgone wage income in this period. Thus, young women's wages are a key determinant of fertility decisions in our model. However, what matters is not the absolute level of the young female wage, but the product of the wage and the marginal utility of consumption. The marginal utility of consumption, in turn, is driven by the present value of a couple's lifetime income. In the balanced growth path, female wages increase in proportion to lifetime income, so that fertility rates are constant.[13]

The tradeoff for having another child is more complicated for women who would adjust their labor supply later in life if they had another child, in which case relative wage at older ages is also relevant. However, this margin operates only for relatively few women. The fertility implications of the war shock in our model are therefore primarily driven by the shock's impact on young women's wages relative to young couples' lifetime income. The shock affects this ratio mostly because it lowers the wage of women relative to men. Given that the major portion of a couple's lifetime income is earned by the husband, a decline in the relative female wage also lowers the ratio of the wage to the present value of a couple's lifetime income. A second channel is that the war shock lowers current relative to future wages (for both men and women), because the capital stock declines relative to the balanced growth path in response to the shock, while total labor supply increases. To assess the quantitative significance of these effects, we now turn to the calibration procedure for our model economy.

4 Calibrating the Model to the U.S. Pre-War Economy

Our ultimate objective is to quantify the implications of a one-time demand shock to female labor for the evolution of fertility in our model. Consistent with this

[13]For fertility to be constant (and thus for a balanced growth path to exist) it is key that the full cost of a child is proportional to income, which is the case here because children are only costly in terms of time.

objective, we calibrate the model such that the balanced growth path matches a specific set of characteristics of the actual U.S. economy. For the macro side of the model, we choose a set of target moments that characterize long-run U.S. growth and that are standard in the real-business-cycle literature. Fertility and patterns of female labor-force participation are matched to observations in the pre-war period, mostly from the 1940 census. In addition, parameters that govern the persistence of female labor supply are chosen such that when exposed to the wartime demand shock for female labor, the model matches the increase in the labor-force participation of older women in the period immediately after the war (i.e., until 1950). This calibration strategy is consistent with our aim of assessing the reaction of younger women in terms of fertility to the increased labor supply of older women.

The first calibration choice concerns the length of a model period. The main characteristic that defines a period in the model is that women can have one child per period. In the balanced growth path, once they start to have children women give birth to a child every period until reaching the fecundity limit M. The length of the model period therefore corresponds to the average time between births. In the United States, the average spacing of births narrowed from over three years for the cohort of mothers born 1916–1920 to slightly above two years for the cohort 1931–35 (Whelpton 1964). As a compromise, we set the model period as corresponding to 2.5 years in the data. We also set the length of childhood to $I = 8$, so that the age of adulthood corresponds to 20 years in the data. The fecundity limit is set at $M = 4$ (women are fecund until 32.5 years old), the last period of work is $R = 15$ (retirement starts at age 60), and the last period of life is $T = 19$ (people die at age 70). In the real world, of course, women can conceive at ages older than 32.5, but the likelihood of conception declines from the early 30s. More importantly, in the model women have children right up to the end of their fertile period, which implies that the fecundity limit determines the average age at first birth. Choosing a higher fecundity limit would imply a counterfactually high age of first-time mothers.

At the aggregate level, we match the capital income share, the depreciation rate, and the return to capital to long-run U.S. data. Where possible, we use the same calibration targets as Greenwood, Seshadri, and Vandenbroucke (2005) for these macroeconomic statistics to yield comparable results. Consequently, we set the capital income share to 0.3 ($\alpha = 0.3$), the depreciation rate to 4.7 percent per year ($\delta = 1 - (1 - 0.047)^{2.5}$), and the annualized return to capital to 6.9 percent.[14] The return to capital is a function of the capital-output ratio, which, in turn, is mostly governed by the time-preference parameter β. Given the other calibration choices, the return to capital is matched by setting $\beta = 0.91$. Given that our model period corresponds to 2.5 years, this discount factor implies an annual discount rate of about slightly under four percent.[15] We also follow the real-business-cycle literature in assuming that full-time work takes up one-third of discretionary time (Cooley and Prescott 1995). Given that the time cost of full-time work is normalized to one (i.e., $l_{t,j} \in \{0, 1\}$), the time endowment is set to $h = 3$. The annualized productivity growth rate of the economy is set to 1.8 percent ($\gamma = 1.018^{2.5}$), which corresponds to the average growth rate of real GDP per capita in the U.S. during the period 1950-2003.[16] The parameters ρ and θ govern the substitutability between male and female labor, as well as relative wages. The share parameter θ is chosen to match a ratio of average female to male wages of 0.66 in 1940.[17] The elasticity parameter ρ has been estimated by Acemoglu, Autor, and Lyle (2004) using census data. They suggest a range of 0.583 to 0.762 for ρ; following this estimate, we set $\rho = 0.65$. The implied elasticity of substitution between male and female labor is about 2.9.

The parameters governing the returns to experience in the labor market determine the steepness of age-wage profiles, both in the cross section and over the life cycle. The male experience parameter η_m is chosen to match the return to experience for men in 1940 Census data, which leads to a value of $\eta_m = 0.0625$. The experience accumulation function for women has two parameters, the return to female experience η_f and the depreciation rate ν. We assume that the return

[14] See Cooley and Prescott 1995 for details on how these statistics can be computed from aggregate U.S. data.

[15] Since we model a life-cycle economy, the direct correspondence between the discount factor, the growth rate, and the return to capital that holds in infinitely-lived agent economies does not apply in our framework.

[16] Data from Penn World Table Mk. 6.2, see Heston, Summers, and Aten (2006).

[17] Average wages are computed across ages 20–60 and all race groups from the 1940 Census, see Appendix A.2 for details.

to experience for women and men is the same, $\eta_m = \eta_f = \eta = 0.0625$. We then calibrate ν such that at age 32.5, when women end their fecundity period (in the model), their productivity is larger by a factor of 1.153 compared to age 20. This factor is obtained by estimating an earnings function for women and predicting women's wage at age 32.5. This procedure yields $\nu = 0.0196$.[18]

The child cost parameters are chosen such that the average private cost of a child (which in the model consists of forgone female earnings) amounts to 40 percent of GDP per capita in the balanced growth path, thus matching the estimate by Haveman and Wolfe (1995) of the total private cost of a child in the United States.[19] The curvature parameter in the child cost function ψ (which determines the returns to scale to having children) and the additional cost of young children κ are estimated from U.S. time-use data, which results in $\psi = 0.33$ and $\kappa = 0.23$ (see Appendix A.4 for details). Given these choices, the overall cost of children is matched to its target by setting the level parameter of the child cost function to $\phi = 0.46$.

We impose a uniform distribution for the taste for leisure σ_x in the population. Given this choice, the remaining parameters to be calibrated are the upper and lower bounds of the distribution of σ_x, the fertility weight σ_n in utility, as well as the fixed cost z of reentering the labor market. These parameters jointly govern the fertility rate, the female labor-force participation rate at different ages, and the persistence of female labor supply. The choice of these parameters is critical for the quantitative predictions of our model. In particular, the dispersion of the taste for leisure σ_x is a key determinant of the size of the fertility response to the war shock. To map out the range of responses of the model for different choices of these parameters, we fix only a set of baseline parameters at this stage, and explore the robustness of the results to alternative choices in Section 5.4 below.[20] The baseline parameters are chosen to match a completed fertility rate of 2.4 as

[18] See Appendix A.3 for additional details on the calibration of the return to experience.

[19] This approach to calibrating the cost of children has been previously used by Doepke (2004), Erosa, Fuster, and Restuccia (2006), and Lagerlöf (2006), among others.

[20] In principle, it would be possible to pin down a single set of parameters by matching additional cross-sectional target moments in 1940. However, given that our model incorporates only a single dimension of heterogeneity, such a procedure may lead to misleading results regarding the key elasticities in response to the war shock. We therefore believe that a sensitivity analysis for these parameters is more informative.

Parameter	Interpretation	Value
I	Duration of childhood	8
M	Final period of fecundity	4
R	Final period before retirement	15
T	Lifespan	19
α	Capital share	0.3
δ	Capital depreciation rate	0.113
θ	Weight of female labor in technology	0.34
ρ	Elasticity of substitution parameter	0.65
γ	Productivity growth rate	0.046
β	Time discount factor	0.91
σ_n	Utility weight on fertility	1.522
$\min(\sigma_x)$	Minimum utility weight on leisure	0.983
$\max(\sigma_x)$	Maximum utility weight on leisure	1.228
z	Cost of labor market reentry	0.8
h	Time endowment	3
ϕ	Level of time cost of children	0.46
ψ	Curvature of time cost of children	0.33
κ	Additional cost of young children	0.23
η_m	Male return to experience	0.063
η_f	Female return to experience	0.063
ν	Depreciation of experience	0.02

Table 1: Calibrated Parameter Values (Baseline Calibration)

well as a full-time equivalent labor-force participation rate of married women aged 33–60 of 13 percent. The latter statistic matches data from the 1940 U.S. Census.[21] The fertility rate of 2.4 matches the completed fertility rate of women born between 1911 and 1915, who were in their prime fertility years (average age 27) in 1940. We choose to match a completed fertility rate rather than the total fertility rate because total fertility rates are sensitive to changes in the timing of births. For the baseline calibration, we also require that the initial response of the labor-force participation rate of younger and older women to the war shock matches empirical observations (see Figure 8 below). These targets are matched by choosing $\sigma_n = 1.522$, $\min(\sigma_x) = 0.983$, $\max(\sigma_x) = 1.228$, and $z = 0.8$. In the sensitivity analysis in Section 5.4 we explore results with alternative parameterizations that continue to match the fertility rate and the labor-force participation rate of older women in 1940, while varying the dispersion of the taste for leisure and the fixed cost of labor market reentry z. The calibrated baseline parameter values are summarized in Table 1.

5 The Experiment: World War II and the Baby Boom

5.1 Modeling the War Shock

We now want to demonstrate how a one-time demand shock for female labor affects fertility and labor-force participation rates in our model. The economy is in the balanced growth path when the war shock arrives. We model the war as a decline in the availability of male labor as well as a decline in the fixed cost of entering the labor market. The decline in male labor is matched to the actual male mobilization rate during the final years of the war. This drop amounts to 30 percent relative to the male labor force in 1940.[22] The decline in the adjustment cost of labor market reentry is chosen to match the increase in the overall female labor-force participation rate in the final years of the war. In the model, the wage increase triggered by a one-time decline in male labor supply is not sufficient to increase female participation by the amount that was actually observed in the war. Indeed, Mulligan (1998) argues that in the United States after-tax real wages

[21]See Appendix A.2 for details.
[22]See Appendix A.5 for details.

Illustration 1: U.S. Government World War II Recruitment Posters

actually fell during the war, so that other factors are required to explain the large increase in female labor-force participation. Patriotism is one such explanation. The U.S. government ran a public campaign to recruit women for the war effort (see Illustration 1). Whereas previously society was often prejudiced against the employment of married women, during the war joining the labor force was actively encouraged. Following this argument, we feed a one-time decline in the fixed cost z into the model in order to match an overall female labor-force participation rate of 34 percent in the war period (Acemoglu, Autor, and Lyle 2004). It turns out that matching this number requires lowering z all the way to zero during the war.

Both changes (the decline in male labor supply and the decline in the fixed cost of entering the labor market) last only one period. However, the shock still has long-term effects, mainly because of persistence in female labor supply. For the most part, the war draws older women into the labor force (the youngest women are working anyway, and women who are currently having children are less willing to enter). Once these women have paid the fixed cost of entering the labor market and have accumulated experience, many of them choose to stay on working after the war. This increases the ratio of female to male labor supply, and depresses

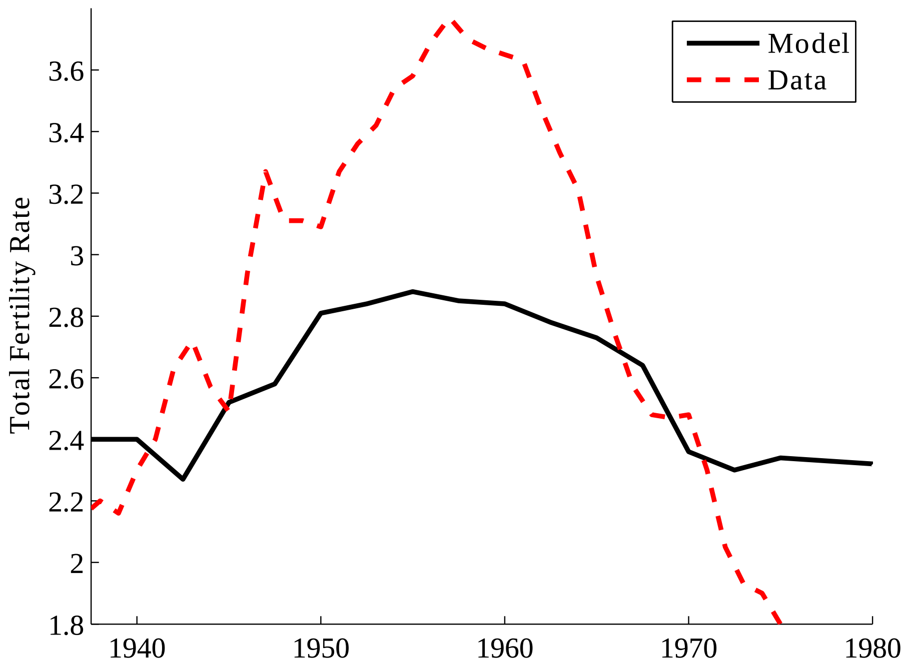

Figure 5: Total Fertility Rate, Model versus Data

female wages. It is this decline in the relative female wage after the war which is responsible for most of the long-term effects of the shock.

5.2 Implications for Fertility

Figure 5 displays the response of the total fertility rate to the war shock in the model. The fertility rate rises steeply in the years after the war, and reaches a maximum of 2.9 in 1955. Subsequently, the fertility rate starts declining with increasing speed, until it evens out slightly below the balanced-growth level in the 1970s. Fertility rises in the post-war period because young women find it less worthwhile to participate in the labor market given the increased labor market competition. In essence, the experienced war generation crowds out young women from the labor market. The young women stay at home and have more children instead.[23] This effect fades out in the 1960s as the older cohorts of

[23]More precisely, a larger fraction of women exits the labor market early in order to have a third child. All families have either two or three children, so that the total fertility rate is driven by the

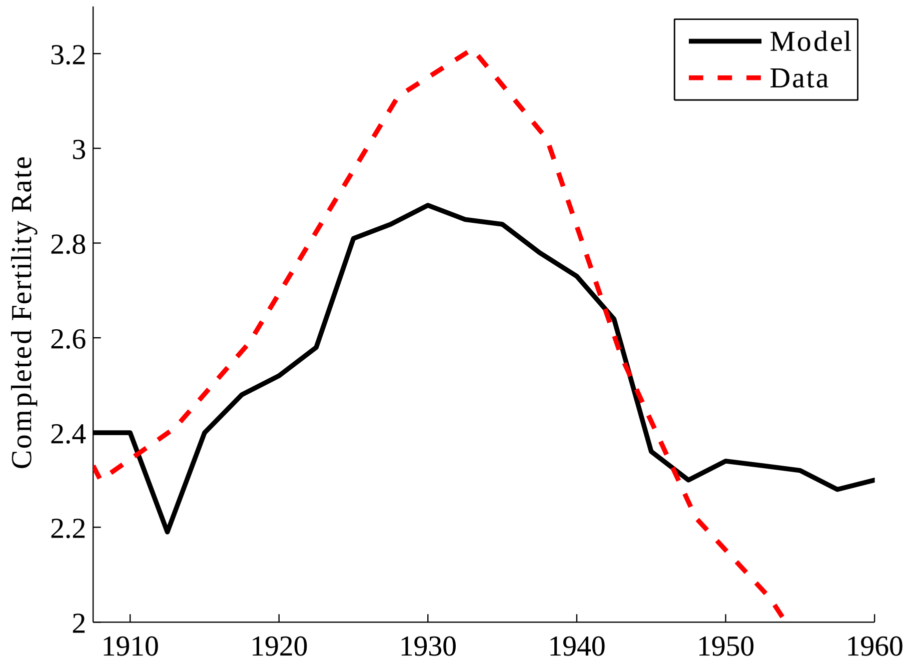

Figure 6: Completed Fertility Rate by Birth Cohort, Model versus Data

women that worked during the war start to retire. Thus, the model also generates an endogenous baby bust.

Figure 5 also displays the actual time path of the total fertility rate in the United States. The comparison of model and data may appear to suggest that the theory does well at explaining the timing of the baby boom and baby bust, but falls a bit short on the quantitative dimension. In particular, in the data the total fertility rate reaches a maximum of 3.8, which is considerably higher than the maximum fertility rate of 2.9 in the model. However, the total fertility rate is also a somewhat misleading guide to fertility behavior, because this measure is highly sensitive to changes in the timing of births. The sharp increase of the total fertility rate in the United States in the 1950s is partially due to a coincidence of a delay of child bearing by older cohorts with earlier child bearing by younger cohorts. Thus, summing age-specific fertility rates during this period results in high mea-

increase in the fraction of three-child families.

sured total fertility rates, even though the increase in fertility is smaller at the level of each individual cohort.[24]

A more informative comparison between model and data can be obtained by considering completed fertility rates, i.e., the average lifetime fertility of specific birth cohorts. This measure is more informative in the sense that it represents the actual fertility behavior of a well-defined group of people. Figure 6 displays the comparison of completed fertility rates between model and data, where the horizontal axis now denotes the birth year of the mother. The figure shows that in terms of completed fertility, the model explains a substantial fraction of the increase during the baby boom. The maximum cohort fertility rate in the data is 3.2, which compares with a maximum cohort fertility rate in the model of 2.9. The model also does very well in terms of the timing of the baby boom and baby bust.

One of the key implications of our theory is that the World War II shock had asymmetric effects on younger and older women. In our theory, it is younger women who did not work during the war who are crowded out of the labor market and decide to have more children. This implication is in line with evidence on fertility by age for the United States. As shown in Figure 4, the increase in fertility was not uniform across the different age groups. Women aged 30 years or older show hardly any increase in fertility during the baby boom. Mothers aged 20–24 had by far the largest increase in fertility. Most mothers in this group were too young to work during the war. In particular, for the two age groups 20–24 and 25–29 fertility peaks in 1960. These mothers were aged between 5 and 15 at the end of the war.

One way to compare the predictions of who is having babies during the baby boom between model and data is to look at the average age at first birth. In the model, all women complete their fertility by age 32.5. The increase in fertility during the baby boom is entirely accounted for by an earlier start of the fertility period. Figure 7 displays the average age at first birth in the model and in U.S. data. In both cases, the average age at first birth drops substantially during the

[24] The model does not allow for the possibility of delayed child bearing, and therefore cannot reproduce this change in the timing of births.

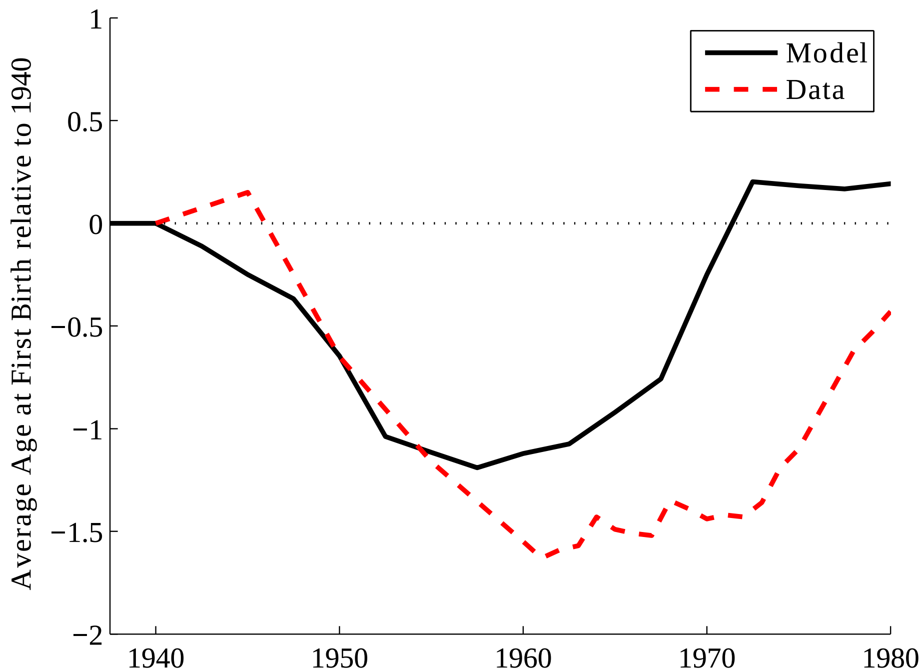

Figure 7: Average Age at First Birth, Deviation from 1940, Model versus Data

baby boom period, and then recovers.

5.3 Implications for the Female Labor Market

In our theory, the increase in fertility during the baby boom is driven by changes in the female labor market. Figure 8 displays labor-force participation rates for women aged 20–32 (the prime child-bearing years) and 33–60. The figure shows the stark asymmetry of the impact on younger and older women. Older women are drawn into the labor force, which accounts for a large increase in participation until the war cohorts retire. In contrast, the younger women lower their labor-market participation because of the increased competition from older women.

The initial response of both young and old labor-force participation rates closely matches the U.S. data. This is no surprise, since we calibrated the model to match these initial responses. After 1950, we observe a sustained increase in the employment of older women in the data, whereas in the model participation rates

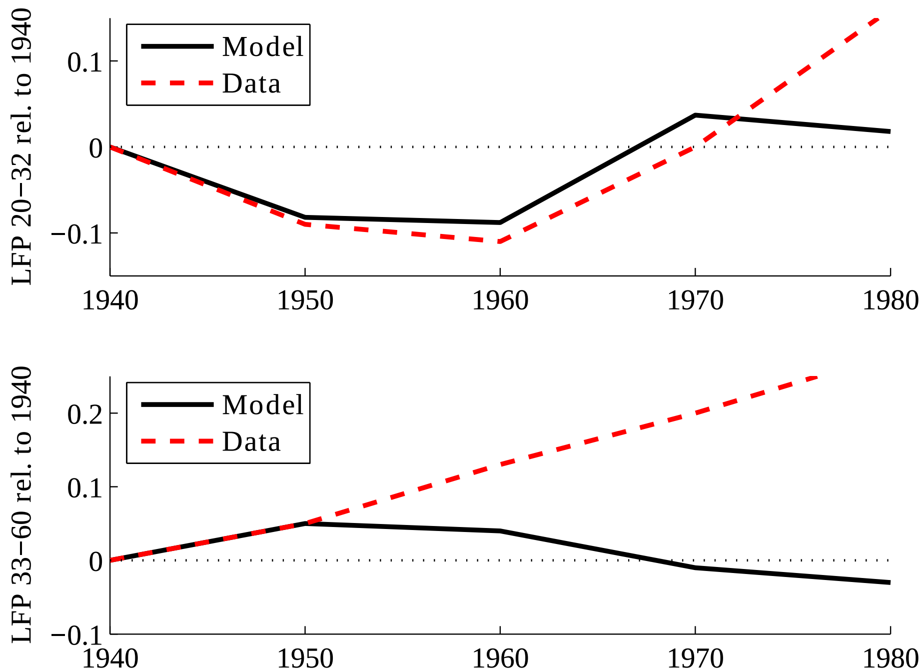

Figure 8: Average Labor Force Participation by Age Group, Deviation from 1940, Model versus Data. Data for ages 20–32 is for all women, and data for ages 33–60 is for married women. See Appendix A.2 for details.

ultimately return to the balanced-growth value. The model does well, however, at tracing the labor-force participation rates of younger women until 1970, i.e., through the entire baby boom and baby bust period.

In the model, the changes in fertility are ultimately driven by changes in the wages paid to young women. For our results to be plausible, it is important that the model does not overstate the wage implications of the rise of female employment. The lower panel of Figure 9 displays the average wage of young women (20–24) in the model as a fraction of the average wage of men in the same age group. Since these women are permanently employed, there is no variation in average labor market experience in this group over time, so that variations in the wage are entirely due to changes in the wage per efficiency unit of female labor. Reassuringly, the decline in the relative female wage from 1940 and 1950

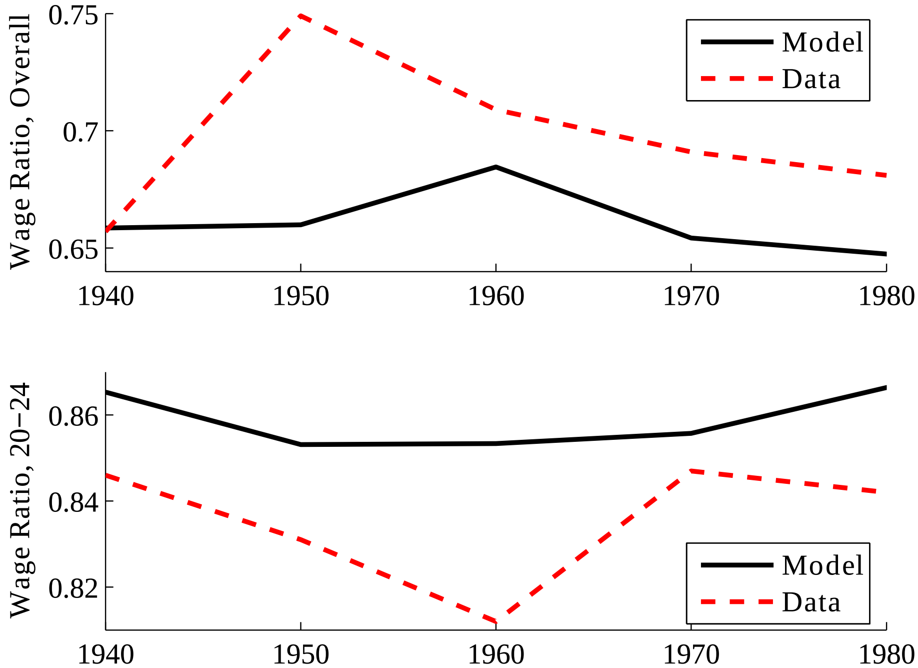

Figure 9: Ratio of Average Female to Average Male Wage for All Women and for Single Women aged 20–24, Model versus Data. See Appendix A.2 for details.

closely matches the data.[25] In addition, both model and data show a recovery of the relative wages of young women during the baby bust period.[26]

The upper panel of Figure 9 displays the overall ratio of female to male wages, averaging over ages 20–60 and all marital statuses. The key point of the figure is to show that the decline in the relative female wage per efficiency unit *does not* imply that the average wage of women declines relative to that of men. The average wage is driven not just by the wage per efficiency unit, but also by the

[25]This result suggests that the estimate of Acemoglu, Autor, and Lyle (2004) of the substitution elasticity between male and female labor is consistent with aggregate data. Notice that female wages decline only in relative, but not in absolute terms: sustained productivity growth implies that average wages rise for both men and women.

[26]The data probably understate the true decline in the relative female efficiency wage between 1940 and 1950, because the average education of women increased relative to men during this period. Selection issues may also be present, but are unlikely to be a major problem because (in the data) we focus on the wages of single men and women aged 20–24, the vast majority of whom were working.

accumulation of work experience, i.e., the average efficiency units of labor per female worker. The war shock creates a cohort of women who continue to work for a long time, and thereby accumulate substantial experience. As a consequence, in the model the average relative wage of women increases until 1960, despite the decline in the relative wage per efficiency unit. Conversely, after 1960 the relative female wage begins to fall, even though the relative wage per efficiency unit is rising. At this time, the experienced war generation of women is retiring and being replaced by less experienced female workers.

Even though our theory accounts for only one component of the gender gap (most importantly, we do not model the return to education), the broad predictions of the model for the overall gender gap are consistent with the data. As the model, the data show an initial increase in the relative female wage, followed by a deterioration that lasts until 1980 (more recently, rising relative education levels have substantially increased the relative female wage). The main deviation is that the increase in the relative female wage until 1950 is much larger in the data than in the model. One explanation for this could be the existence of an age premium, rather than just an experience premium.

In terms of predictions for fertility, what matters is the model's ability to account for the dynamics of the labor market for young women. Here we see that the model is quite successful in accounting for the evolution of both relative wages and the employment level of young women. These findings support the quantitative importance of our mechanism.

5.4 Sensitivity Analysis and Discussion

The size of the fertility response in our model depends crucially on the distribution of the taste-for-leisure parameter σ_x in the population. Intuitively, fertility increases because a larger fraction of families decide to have three instead of two children. Thus, the fertility response is large if the density of the distribution of σ_x near the point of indifference between two and three children is high. Other things equal, a compressed distribution of σ_x therefore leads to a larger fertility response compared to a distribution that is more spread out.

In the calibration procedure described in Section 4, the distribution of σ_x is pinned

	Change in Calibration Procedure	
Parameter	Dispersed Leisure Taste	High Reentry Cost
σ_n	1.526	1.521
$\min(\sigma_x)$	0.926	0.947
$\max(\sigma_x)$	1.390	1.183
z	0.87	0.91

Table 2: Calibrated Parameter Values (Alternative Calibrations)

down by matching the initial fall in the labor-force participation of younger women (i.e., until 1950) between model and data. Implicitly, this procedure assumes that the initial fall in young female participation is entirely due to the increased labor-force participation of older women. If other, unrelated factors also depressed young female labor-force participation in 1950, our procedure might lead to an overestimate of the quantitative impact of the war-related demand shock for female labor on post-war fertility. To address this concern, we explore the sensitivity of our results to other assumptions on the distribution of σ_x. In particular, the second column of Table 2 presents an alternative parametrization in which the range of σ_x is twice as large as in the baseline calibration. In the baseline case, the upper bound and lower bounds of the distribution $\max(\sigma_x)$ and $\min(\sigma_x)$ satisfy $\max(\sigma_x)/\min(\sigma_x) = 1.25$, while in the alternative calibration we set $\max(\sigma_x)/\min(\sigma_x) = 1.5$. The utility weight of fertility σ_n and the reentry cost z are adjusted such that the balanced growth path continues to match the balanced-growth fertility and labor-force participation targets as well as the initial increase in the labor-force participation of older women (all other parameters remain the same). We no longer match the initial decline in young female participation, which is smaller in the alternative calibration given the increased dispersion of the taste for leisure.

Figure 10 compares the fertility response in the baseline calibration (solid line) with the response in the alternative calibration with a dispersed taste for leisure (dashed line). The main message emerging from the figure is twofold. First, the alternative calibration leaves the qualitative response of the model to the war

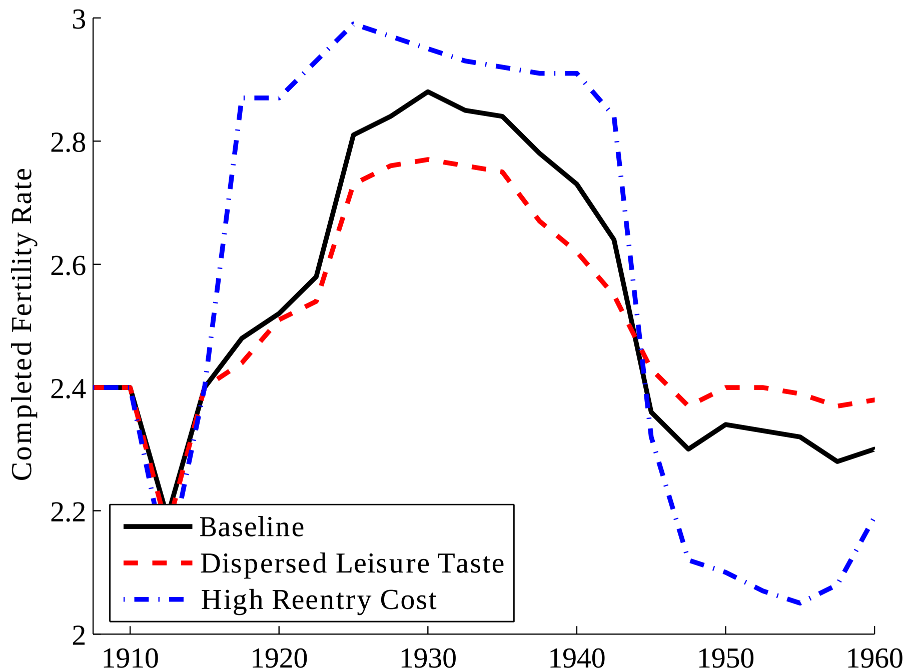

Figure 10: Sensitivity of Predictions for Completed Fertility Rate

shock unchanged: the timing of the rise and fall of fertility continues to line up well with the data. Second, the size of the fertility response declines relative to the baseline case, but only by a small amount. In the baseline case, the maximum fertility rate is 2.9, whereas in the alternative calibration it is 2.77. Thus, the model continues to account for a substantial portion of the observed increase in completed fertility. If we double the range of the distribution of σ_x yet again ($\max(\sigma_x)/\min(\sigma_x) = 2$), qualitatively the results continue to resemble the baseline case, and the maximum fertility rate drops to 2.64. Thus, even under this parameterization (which implies, counterfactually, a decline in young female labor-force participation only half as large as observed in the data) the model still accounts for one-third of the observed increase in cohort fertility.

It is a strength of our mechanism that it can be quantitatively assessed by comparing the model's prediction for variables other than fertility (such as labor-force participation rates) to data.[27] The sensitivity analysis suggests that there is some uncertainty about the exact size of our mechanism's contribution to the baby boom, but that the contribution is substantial over a wide range of plausible parameterizations. Given that it is unlikely that a single mechanism on its own can account for the entire baby boom, we believe that explaining even one-third the increase in fertility is a considerable success.

So far, we have focused on alternative parameterizations which lower the size of the baby boom generated by the model. However, other arguments can be made which suggest that the quantitative significance of our mechanism may be even larger than suggested by the baseline results. In particular, our model assumes that the increase in labor supply by older women after the war is entirely due to the impact of the war on individual employment histories. In other words, the only women who work more after the war are the ones who gained labor-market experience during the war. It has been argued,[28] however, that the overall impact of the war on female employment was much larger. If the employment of older married women was depressed partially because of prejudice and misinformation,[29] the wartime increase in female employment may have additional long-term effects, because it triggers learning that lowers barriers for future female employment even for women who did not work during the war. The data indeed appear to be consistent with this interpretation: the further increase in the employment of older women after 1950 was largely driven by the entry of women with little prior work experience. In addition, Fernández, Fogli, and Olivetti (2004) show that the wartime increase in female employment may have had a substantial impact a whole generation later, when the sons of work-

[27]To our knowledge, the existing alternative explanations for the baby boom have not been quantified in this manner. To the extent that the effects are quantified at all, the authors rely on estimation procedures which fit fertility rates directly, thus maximizing, but also possibly exaggerating, the importance of each mechanism. In contrast, the key feature of our calibration procedure is that it does not constrain the size of the fertility response, i.e., the rise and decline of fertility during and after the baby boom do not appear as a target moments.

[28]See Fernández, Fogli, and Olivetti (2004), Fernández (2007), and Fogli and Veldkamp (2007) for recent contributions, as well as the discussion in Section 2.

[29]One indication that this interpretation may be relevant is that our calibration procedure yields an adjustment cost z for labor market reentry that is too large to be entirely accounted for by job-search costs, and thus possibly reflects other barriers to the employment of married women (such as prejudiced husbands).

ing women proved more supportive of their own wives' employment compared to sons of stay-at-home moms.

While a full analysis of this mechanism is beyond the scope of this paper, we explored an alternative calibration that ascribes a higher increase in the employment of older women to the war shock. Specifically, rather than matching the employment of older women in 1950, we recalibrated the model such that it matches the average of the employment of older women in 1950 and 1960. This is accomplished mainly by increasing the persistence of labor supply through choosing a higher reentry cost z. The third column of Table 2 presents the parameter values that match this target (in addition to the usual pre-war targets for fertility and labor-force participation). The dash-dotted line in Figure 10 displays the corresponding fertility path. Once again the qualitative features of the transition remain the same, but now the maximum fertility response increases further to 2.99. Thus, if we interpret the contribution of World War II to the rise in female employment more widely, the model can plausibly account for most of the increase in fertility during the baby boom.

A possible objection to our analysis is that the model matches only the initial increase in older female labor-force participation until 1950, but not the further increase from 1960 on. In the model simulations, labor-force participation rates return to the level of the pre-war balanced growth path, whereas in the data we observe a permanent upward shift in female employment. A natural question to ask is whether our model could still account for the timing of the baby boom and baby bust if we also matched the entire time path of the employment of older women. Indeed, if we exogenously fed the entire time path of the labor-force participation of older women into the model without changing other parameters, wages for young women would be permanently depressed, and the baby boom would persist. However, the rise in fertility is due not to the increase in the labor-force participation of older women *per se*, but due to lower wages for younger women. Here the data show that wages recovered after 1960, which is in line with the predictions of our model regarding the end of the baby boom. These observations suggest that the demand for female labor increased over time, so that the substantial further increase in female labor-force participation after the baby boom period no longer depressed female wages.[30]

6 International Evidence: Allied versus Neutral Countries in World War II

We now turn to international evidence to assess the empirical relevance of our mechanism from a different perspective. Most industrialized countries experienced a baby boom after World War II, but only some of them also underwent a substantial mobilization of female labor during the war. Our theory predicts that countries with a larger wartime increase in the female labor force should also experience larger baby booms. We assess this prediction by comparing the baby boom in two sets of countries: the Allied countries that, like the United States, did not fight on their own soil (Australia, Canada, and New Zealand), and the major European countries that remained neutral in the war (Portugal, Spain, Sweden, and Switzerland).[31] The results confirm our hypothesis. The Allied countries mobilized a substantial fraction of working-age men for the war, which resulted in a large increase in female labor-force participation. Subsequently, all of the Allied countries experienced a baby boom and baby bust that is remarkably similar to that of the United States. In contrast, in the neutral countries the war did not mark a watershed for female labor-force participation, and the post-war baby boom was of a much smaller magnitude than in the Allied countries. In what follows, we present more detailed information on the involvement of these two groups of countries in the war and their subsequent fertility experience.

[30] An interesting extension to our analysis would be to also model the secular increase in the demand for female labor, for example by calibrating a second balanced growth path to more recent data (say, the 1980 or 1990 census), and then computing a transition path between the original and the new balanced growth path. We conjecture that the implications of the war shock relative to this transition path would be similar to our results here.

[31] Australia was subject to some aerial bombing and naval shelling, but destruction was on a much smaller scale than in the United Kingdom. We do not have a theory of the impact of wartime destruction on subsequent fertility, and therefore omit the countries most directly affected by the war from our analysis (however, including the United Kingdom in the Allied group would lead to the same overall conclusions).

6.1 The Allied Countries: Australia, Canada, and New Zealand

Australia joined the war on September 3, 1939, the same day Britain and France declared war on Germany. In September 1939, only 14,903 men were enlisted in the Royal Australian Navy, the Australian Military Forces, and the Royal Australian Air Force. Enlistment grew rapidly, however: by November 1941, 364,874 men were enlisted, and within less than a year the size of the armed forces nearly doubled to 634,645 in August 1942. During the years 1942–1945, between 23 and 27 percent of all males age 15–64 were serving in the armed forces.[32] New Zealand joined the war on the same day Australia did. In September 1939, 20,806 men were serving, but this number grew rapidly to a peak of 154,549 in July 1942. During the years 1942–1944, between 30 and 37 percent of all males age 20–59 were serving in the armed forces.[33] Canada joined the war seven days after Australia and New Zealand. At that time, only 9,000 individuals were in the armed services. By 1941 enlistment had reached 296,000, and the peak was reached in 1944 with 779,000 men under arms. At this time, nearly 19 percent of all males age 15-64 were serving in the armed forces.[34]

As in the United States, the mobilization of men led to a large increase in female employment during the war, with active encouragement by government campaigns (see Illustration 2). For the generation of women old enough to work during the war, the increase in labor-force participation persisted in the following decades. For example, in Canada the labor-force participation of women aged 35–64 increased by more than 30 percent between 1941 and 1951 and by another 50 percent between 1951 and 1961. In contrast, the participation rate of women aged 25–34 in 1951 was down nearly 10 percent compared to 1941, and by 1961 it exceeded the 1941 level by merely 5 percent.[35] This pattern closely resembles our findings for the United States.

[32] Authors' calculation using series WR24, POP211 and POP274 in Vampley (1987).

[33] Authors' calculation using Tables II.4 and VIII.17 in Bloomfield (1984).

[34] Authors' calculation using series A32-A41 and C48 in Urquhart and Buckley (1965).

[35] Source: Historical Estimates of the Canadian Labour Force, 1961 Census Monograph, Statistics Canada, Catalogue 99-549. The data for New Zealand and Australia are less detailed. For Australia, Beaton (1982) reports that the total number of employed women during the war rose by nearly 200,000 between 1939 and 1943, and while it had dropped by nearly 70,000 from that peak by 1946, by 1948 the total number of employed women had risen above the 1943 peak by 4000.

Illustration 2: Australian Government World War II Recruitment Poster

The fertility dynamics in the Allied countries in the post-war period display a striking resemblance to the United States. Figure 11 displays the completed fertility rate in the United States, Canada, Australia, and New Zealand for women born between 1910 and 1960.[36] In all four countries, the completed fertility rate increased steadily from the cohorts born in the 1910s to those born in the early 1930s. Subsequently, completed fertility declined in all four countries. In the United States and Australia, the completed fertility rate peaks for women born in 1932. In Canada the peak is reached with the 1931 birth cohort, and in New Zealand with the 1930 cohort. The similarity of the fertility experience of these countries concerns not only the timing but also the magnitude of the baby boom. Measured as the absolute difference between the completed fertility rate of women born in 1913 and women born in the early 1930s, the size of the baby boom equals 0.8 in the United States and New Zealand, 0.79 in Australia, and 0.48 in Canada.

6.2 The Neutral Countries

Four major European countries remained officially neutral in World War II: Portugal, Spain, Sweden, and Switzerland. While there was some wartime mobiliza-

[36]Data on completed fertility rate were kindly provided by Jean-Paul Sardon of the Observatoire Démographique Européen. Some of these data are published in Sardon (2006).

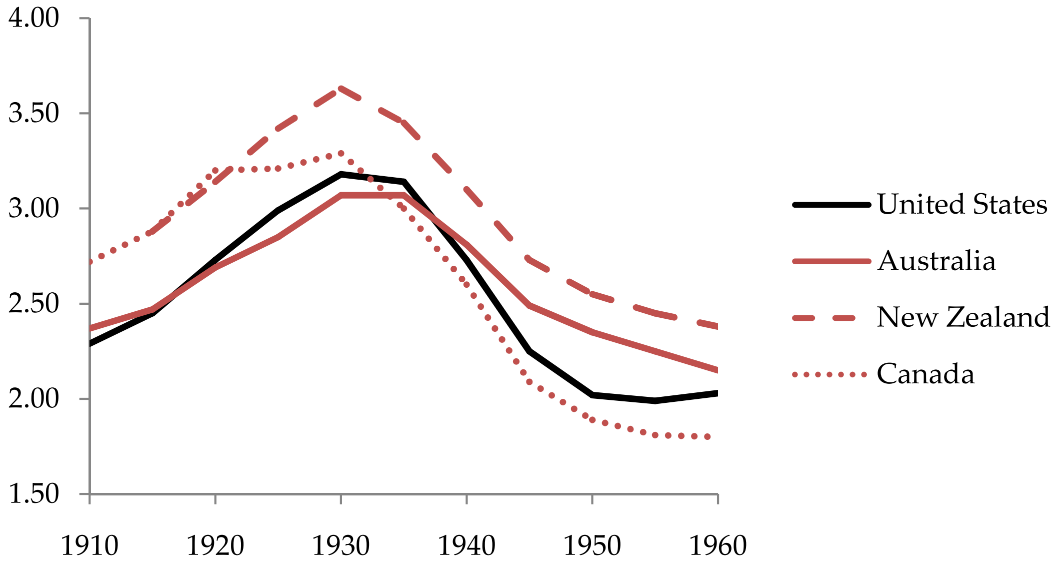

Figure 11: Completed Fertility Rate in Canada, Australia, New Zealand, and the United States

tion even in these countries (in particular in Switzerland), these countries did not experience a substantial increase in female employment during the war.[37] Our mechanism for the baby boom therefore does not apply to these countries, and consequently we would expect to observe smaller post-war baby booms (which must then be due to other mechanisms). Figure 12 shows the completed fertility rate in the four neutral countries in comparison to the United States. The figure shows that Portugal did not experience any baby boom at all. Fertility did go up in Spain, Sweden, and Switzerland, but much less so than in the United States. Sweden experienced the largest increase in fertility among the neutral countries, but even here the size of the baby boom is only 0.22, less than half of the increase in Canada, which displays the smallest increase among the Allied countries.

In sum, the international evidence suggests that our mechanism is quantitatively important for explaining the baby boom and baby bust of the 1950s and the 1960s. Allied countries that experienced a large wartime increase in female employment also had much larger subsequent baby booms than neutral countries. In our com-

[37]Nor did female participation rise quickly after the war. For example, Sweden and Switzerland do not show any marked increase in the female labor-force participation rate between 1940 and 1960.

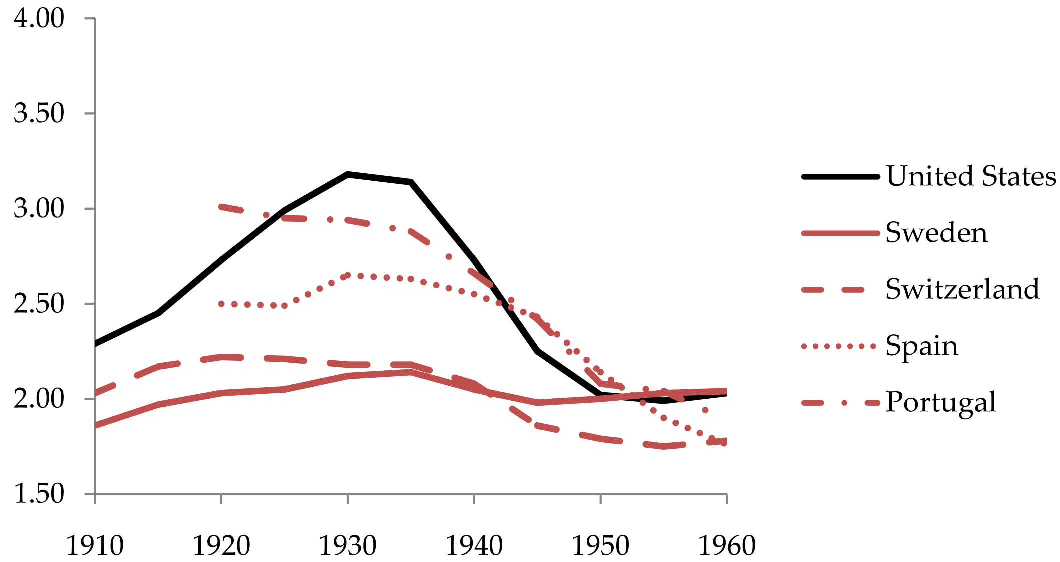

Figure 12: Completed Fertility Rate in Portugal, Spain, Sweden, Switzerland, and the United States

parison, we have have focused on the completed fertility rate as a measure of fertility, because it corresponds most closely to the predictions of our model. However, carrying out the comparison in terms of the total fertility rate would lead to the same conclusions.

7 Conclusions

In this paper, we have proposed a simple theory that links the post-war baby boom to demand for female labor during World War II. Existing theories of the baby boom have dismissed a causal link between the war and increased fertility, mainly because the baby boom extended for 15 years after the war and is too large to be explained solely by "catch up" fertility. Our theory, however, does not rely on "catch up" fertility, but on the demand for female labor.

We show that if labor market experience is valuable, a one-time demand shock for female labor leads to persistent, asymmetric effects on the labor supply of younger and older women. World War II was a huge demand shock for female labor: average female participation jumped from 28 to 34 percent between 1940 and 1945 (Acemoglu, Autor, and Lyle 2004), and among women whose husbands served in the armed forces participation rates exceeded 50 percent. We show that such a demand shock should lead to a temporary baby boom and an asymmetric evolution of the labor-force participation of older and younger women in the decades after the shock. We find, indeed, that age-specific fertility and labor-force participation rates after the war behave just as predicted by this theory. Our quantitative analysis suggests that the mechanism can account for a major portion of the rise and fall in completed fertility rates during the baby boom and baby bust periods.

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A Data and Calibration Appendix

A.1 Fertility Data

Data on total fertility rates (TFR) in Figures 1 and 5 are taken from Chesnais (1992), Tables 2A.3 and 2A.4, pp. 545–548. Data on completed fertility rates in Figures 2 and 6 are taken from Jones and Tertilt (2006), Table A1, p. 56, and from Sardon (2006). The data on birth rates by age of mother in Figure 4 are from the Vital Statistics of the United States, 1999, Volume I, Natality (Table 1-7). The average age at first birth is computed from data on first birth rate by age, taken from the Historical Statistics of the United States, Millennial Edition, Vol. 1, Table Ab150-215, pp. 412–413.

A.2 Labor Supply and Wages

Statistics on labor supply and wages are computed from census data. Specifically, we use data from the 1 percent Integrated Public Use Microsample (IPUMS) of the Decennial Census for the decades 1940 to 1990. For 1940, 1950, 1960, 1980 and 1990, we use the general 1 percent sample. For 1970 we use the Form 2 Metro sample. The data are weighted using the appropriate weighting scheme (see Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander 2004). We restrict our attention to individuals aged 20–60, living in non-farm households, and whose group quarter status is equal to 1, "Households under the 1970 definition."

Total hours worked in the previous year is computed by multiplying weeks worked last year (WKSWORK1) by hours worked last week (HRSWORK1). In 1960 and 1970, Census information on weeks worked last year and hours worked last week are reported only in intervals (WKSWORK2 and HRSWORK2, respectively). Therefore, for these decades, weeks worked last year and hours worked last week are assigned the midpoint value of each interval as in Fernández, Fogli, and Olivetti (2004).

The variable weeks worked last year (WKSWORK1) is not comparable across all years. Specifically, as noted by Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander (2004), in 1940 "It was up to respondents to determine precisely what "full-time" meant in their specific locality, occupation, and industry. If respondents did not know how many hours should be regarded as a full-time week, enumerators were instructed to suggest that 40 hours was a reasonable figure. In essence, respondents were to estimate how many hours they had averaged per week, multiply this figure by 52 weeks, then divide by about 40."

To assure comparability between 1940 and subsequent Census years, we took the following steps. For individuals who reported 52 weeks in the previous year or less than 52 weeks in the previous year but 40 or more hours in the previous week, we left the annual hours unchanged (i.e., WKSWORK1 times HRSWORK1). For those who reported less than 52 weeks in the previous year and less than 40 hours in the previous week, we computed annual hours as weeks worked last year times 40 (i.e., WKSWORK1 times 40).

The measure of labor supply reported in the paper is the ratio between the mean annual hours worked by women to the mean annual hours worked by men in the same group. This measure can be interpreted as a full-time equivalent labor-force participation rate. When comparing model to data (see Figure 8) we use data for all women for the ages 20–32 but for married women for the ages 33-60, because our model does not allow for the possibility of spinsterhood.

For wages and the gender gap, we use the information on wage and salary income (INCWAGE). N/A code (999999) is treated as a missing value. Following Acemoglu, Autor, and Lyle (2004), top-coded values are imputed as 1.5 times the censored value. To obtain hourly wages, INCWAGE is divided by the total hours worked in the previous year. The relative wage of women to men, i.e., 1 minus the gender gap is computed as the ratio of the mean wage of women to the mean wage of men in the same group. For the overall gender gap, we use average wages for ages 20–60. For the gender gap for young women (i.e., before child bearing) we use data on single women aged 20–24 (see Figure 9). While formally in our model all women start out already married, the pre-child-bearing period is best interpreted as corresponding to single life in the data. Empirically, marriage and having one's child were closely related events during the period. In addition, using data for single women is less subject to selection problems, as the vast majority of young single women were working.

A.3 The Accumulation of Work Experience

The experience accumulation function for men has one parameter, the returns to men's experience, η_m. Using 1940 census data, we estimate the earning function:

$$\ln w_i = \alpha + \beta_0 \text{ education}_i + \beta_1 \text{ experience}_i + \epsilon_i$$

for men aged 20–60 using a Heckman selection model. We assume that the selection into the labor force depends on education, marital status and the number of kids under the age of 5. Given that actual work experience is not available, we follow the standard in the labor literature and compute experience as:

$$\text{experience} = \text{age} - \text{education} - 6.$$

We obtain an estimate of the return to experience of $\beta_1 = 0.024565$. Since this is the return to one additional year of experience and in our model a period corresponds to 2.5 years in the data, we set $\eta_m = (1 + 0.024565)^{2.5} - 1 = 0.0625$.

The experience accumulation function for women has two parameters, the return to female experience, η_f and the depreciation rate, ν. We assume that the return to experience for women and men is the same $\eta_m = \eta_f = \eta = 0.0625$. We then calibrate ν such that at age 32.5 when women end their fecundity period (in the model), their productivity would be larger by a factor of 1.153 than at age 20. This factor is obtained by estimating the earning function stated above for women and predicting women's wage at age 32.5. This procedure yields $\nu = 0.0196$.

A.4 The Child Care Cost Function

The level parameter ϕ of the child-care cost function is pinned down using data on the total private cost of children from Haveman and Wolfe (1995), as described in the main text. However, Haveman and Wolfe (1995) do not report information which can be used to back-up the curvature parameter ψ. We therefore use time use data to set ψ. We estimate ψ by running the regression $\ln y_i = \beta_0 + \psi \ln n_i + \epsilon_i$ on time use data. The data come from the American Heritage Time Use Study. Specifically, we follow Hill and Stafford (1980) and use the 1975–1976 American's Use of Time survey. This is a panel study designed and administered by the Survey Research Center at the University of Michigan.[38] We also followed Hill and Stafford (1980) in defining child care as the sum of minutes care for infant, minutes care for older child, minutes medical care for child, minutes play with child, minutes supervise homework, minutes read to/talk to child, and minutes other child care. Restricting attention to women of all marital statuses who live in urban areas, we obtain $\psi = 0.3024$. Similarly, restricting attention to married women, we obtain $\psi = 0.3509$. We use the average of these estimates and fix the curvature parameter at a value of 0.33.

In addition to the two parameters ϕ and ψ, we also need to fix the additional time cost associated with a birth, κ. In the time use data described above, we find that mothers with one child in the age group 0–3 spent somewhat more than twice as many minutes per day than mothers with one child who is older than 3 years old. Since time costs make up only a fraction of the total private cost of children, we set $\kappa = 0.5\phi$.

A.5 U.S. Mobilization for World War II

Data on the mobilization of American men to World War II are taken from U.S. Department of Commerce, Bureau of the Census (1975), series Y904, "Military Personnel on Active Duty." To conversion of the absolute numbers to rates we divide this series by the male population in the age group 20–59. These numbers come from Hobbs and Stoops (2002), Table 5: "Population by Age and Sex for the United States: 1900 to 2000 Part A." Since the population in this age group is available only on a decennial basis, we assume a constant growth rate between 1940 and 1950. This procedure yields mobilization rates of 0.013, 0.049, 0.104, 0.242, 0.303, 0.318, 0.079 and 0.041 for the years 1940–1947, respectively. Hence, a reduction of 30 percent of men availability for one period is based on the average mobilization rate during the 1943-1945 period. Note that this is a conservative reduction as we disregard the decline in men's availability during the 1941–1942 period.

[38]The data are available online at: http://www.timeuse.org/ahtus and were downloaded from this web-site on September 20th, 2007. The 1975–1976 survey was designed as a nationally representative sample of households and sampled both respondents, and, if the respondent was in a couple, the spouse or partner. Four waves of the survey were carried out in order to represent all seasons of the year and all days of the week. The study collected most information from one person per household. However, if the diarist had a spouse, the spouse was asked to complete a cut-down version of the diary and questionnaire.