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Abstract

During World War I (1914–1918) the birth rates of countries such as France, Germany, the U.K., Belgium and Italy declined by almost 50 percent. In France, where the population was 40 millions in 1914, the deficit of births is estimated to 1.36 millions over 4 years while military losses are estimated at 1.4 millions. In short, the fertility decline doubled the demographic impact of the war. Why did fertility decline so much? The conventional wisdom is that fertility fell below its optimal level because of the absence of men gone to war. I challenge this view using the case of France. I construct a model of optimal fertility choice where a household in its childbearing years during the war faces a partially-compensated loss of its husband's income, and an increased probability that its wife remains alone after the war. I calibrate the model's parameters to fit the fertility data over the 100 years before the war, and the probability that a wife remains alone after the war using the casualties sustained by the French army. The model over-predicts the fertility decline by 34% even though it does not feature any physical separations of couples. It also over-predicts the increase in fertility after the war, and generates a temporary increase in the age at birth as observed in the French data.

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1 Introduction

The First World War (WWI) lasted four years, from 1914 to 1918, and ravaged European countries to an extent that had never been seen until then. During the war, the birth rates of countries such as France, Germany, Belgium the United Kingdom or Italy declined by about 50% –see Figure 1. In France, an estimated 1.36 million children were not born because of this decline. This figure amounts to 3.4% of the total French population in 1914 (40 millions), and is comparable to the military losses which are estimated at 1.4 million men.[1] In short, the fertility decline doubled the already large demographic impact of the war.

What prompted such a decline of fertility? Answering this question will shed light on a phenomenon that shaped the European demography for the rest of the Twentieth century. The conventional wisdom is that during the war fertility fell below its optimal level because of the absence of men gone to fight.[2] I challenge this view using the case of France. I develop a model of fertility choice where a household in its childbearing years during World War I faces a partially-compensated loss of its husband's income because of the mobilization, as well as an increased probability that its wife remains alone after the war. Calibrating this probability as the ratio of military losses to the number of men mobilized, and using income data to calibrate a husband's income loss, the model actually over-predicts the fertility decline by 34% even though it does not feature any physical separations of couples. The model also over-predicts the post-war fertility increase and generates, as observed in the data, a temporary rise in

[1]See Huber (1931, p. 413). Military losses include people killed and missing in action. They are a lower bound on the death toll of the war since they do not include civilian losses.

[2]See, for example Huber (1931), Vincent (1946) and Festy (1984).

the age at birth after the war due to the postponement of fertility by the generations affected by the war.

The unit of analysis is a finitely-lived household which, at age 1, comprises two adults: a husband and a wife. A household derives utility from consumption per (adult-equivalent) member and the number of children it gives birth to as well as from the number of adults. It can choose to have children at age 1 (20-25 in the data) and 2 (25-30 in the data), but children are costly. They require time, goods, and a share consumption for an exogenously given number periods (childhood). A husband supplies his time inelastically to the market in exchange for a wage, while a wife splits her time between the market, where she faces a lower wage than a husband, and raising children. The number of adults, from age 2 onward, follows one of two possible regimes. In peacetime it remains 2. During a War it can decrease to 1: there is a probability that a wife remains alone (possibly with children) once peace returns.

The quantitative strategy is the following. First, I calibrate the model's parameters to fit the time series of the French fertility rate from 1800 to the eve of World War I. That is, I consider generations who entered their fertile years before the war broke out, so I assume that the risk that a wife remains alone is zero. Second, using the calibrated parameters I compute the optimal choice of the generations exposed to the war, i.e., generations facing a partially-compensated loss of income due to the mobilization of men, and a non-zero probability that their wives remain alone at the end of the war. I assume that the war is unanticipated. There are a few noteworthy results. First, the war induces a household to save more and consume less than it would have otherwise, thereby raising the marginal utility of its consumption. This results from

(i) the increased uncertainty due to the war; (ii) the reduction of expected income due to the possibility that the wife remains alone and; (iii) the loss of contemporaneous income due to the mobilization. The increase in the marginal utility of consumption raises the cost of diverting resources away from consumption and toward raising children. This effect is magnified by the fact that the expected marginal benefit of a child is lower when the expected number of adults in the household decreases. Thus, the first consequence of the war is an instantaneous reduction of fertility, even though the model does not feature a physical separation hindering a household's ability to have children. Second, the war induces an age-1 household to postpone giving birth. The reason is as follows. Children born to an age-2 household are usually more expensive because the opportunity cost of a child increases with the wage throughout a household's life. But this cost is partly offset by the fact when a household who was young during the war gives birth after the war it faces no more risk. Thus, a household can trade-off risk for a higher cost of raising children. This inter temporal reallocation of births implies an increase in the age at birth that is consistent with the French data.

This paper contributes to an already large literature focusing on the determinants of fertility across countries and over time. Seminal work was done by Barro and Becker (1988) and Barro and Becker (1989). Galor and Neil (2000) analyze the $\cap$-shaped pattern of fertility over the long-run. Greenwood et al. (2005) propose of theory of the baby boom in the United States. Jones et al. (2008) review alternative theories explaining the negative relationship between income and fertility across countries and over time. The effect of a war on fertility is explored, in the case of World War II and the U.S. baby boom, by Doepke et al. (2007). Albanesi and Olivetti (2010) evaluate the effects of technological improvements in maternal health. Jones and Schoonbroodt (2011) theorize endogenous fertility cycles. Manuelli and Seshadri (2009) ask why do fertility rates vary so much across countries? Bar and Leukhina (2010) investigate, simultaneously, the demographic transition and the industrial revolution. Also related is the work by Ohanian and McGrattan (2008): an example where economic theory is used to investigate the effect of a war. In this case the authors evaluate the effect of the fiscal shock that World War II represented for the U.S. economy. Finally, Abramitzky et al. (2011) evaluate the impact of World War I on assortative matching in the marriage market in France. Sommer (2009) shows that in the U.S. since the 1960s, the age at birth is increasing in the degree of labor market risk.

The paper is organized as follows. In the next Section I present facts relative to the number of births and deaths during the war as well as to the composition of the Army. I argue that, although the mobilization was large, even mobilized men might have had the opportunity to have children. I also discuss relevant facts pertaining to the marriage market and the situation of women during the war. In Section 3 I develop the model and discuss the determinants of optimal fertility and, in particular, the mechanisms through which the war changes fertility. Section 4 presents the quantitative analysis of the model that is first the calibration strategy, second the results of the main experiment, third the results of counterfactual experiments decomposing the effects of the two shocks representing the war and, finally, a set of experiments to evaluate the sensitivity of the main results to the choice of some parameters. Section 5 concludes.

2 Facts

Some data are from the French census. The last census before the war was in 1911. The first census in the post-war era was in 1921. A census was scheduled in 1916 but was cancelled. This data, and the data from previous censuses, were systematically organized in the 1980s and made available from the Inter-University Consortium for Political and Social Research (ICPSR). It is also available from the French National Institute for Statistics and Economic Studies (Insee). Vital statistics are available during the war years for the 77 regions (départements) not occupied by the Germans. There was a total of 87 regions in France at the beginning of the war. Huber (1931) provides a wealth of data on the french population before, during and after the war. It also contains a useful set of income-related data.

2.1 Births and Deaths

The demographic impact of World War I in France was large and persistent. Consider Figure 2, which shows the age and sex structure of the population before the war, in 1910, and after the war, in 1930, 1950 and 1970. The differences between the pre- and post-war population structures are quite noticeable. The first effects of the war are visible in the 1930 panel. First, there is a deficit of men (relative to women) in the 30-50 age group. These are the men that fought during World War I and died. Second, there is a deficit of men and women in the teens. This is the generation that should have been born during the war but was not because of the fertility decline. The 1950 panel shows again the same phenomenon 20 years later. The men who died at war should have been in the 50-70 age group, and the generation not born during the war should have been in its thirties. Note also the deficit of births that occurred in the early 1940s, that is during World War II. What caused this? It could have been that, as during World War I, individuals had less children because of World War II. For the French, however, the impact of World War II was quite different than that of World War I, possibly because the fighting did not last as long. In fact, the birth rate in the 1940s shows a noticeable increase.[3] Thus, births were low in the 1940s because the generation that should have been in its childbearing period, say people of age 25 in 1940, should have been born in 1915, that is in the midst of World War I. This generation was unusually small, so it gave birth to unusually little children despite a high birth rate. So, the deficit of births during World War I lead, mechanically, to another deficit in births 25 years later not because of a reduction in fertility, but because of a reduction in the size of the fertile population. The 1970 panel shows that, as late as in the seventies, the demographic impact of World War I is still quite noticeable. The generation that should have been born during the war should, by then, have reached its fifties.

The first month of World War I was August 1914, but the first severe reduction in the number of live births occurred nine months later: it dropped from 46,450 in April 1915 to 29,042 in May –a 37% decline.[4] During the course of the war the minimum was attained in November 1915 when 21,047 live births were registered. The pre-war level of births was reached again in December 1919. To put these numbers in perspective consider Figure 3, which shows the number of births per month in France

[3] One can argue that the baby boom was already under way in the early 1940s in France. Greenwood et al. (2005) propose of theory of the baby boom based on technical progress in the household.

[4] See Bunle (1954, Table XI, p. 309).

and Germany from January 1906 until December 1921. The trend lines provide an estimation of the number of births that would have realized if during the war the trends that prevailed from 1906 to 1914 had remained. For France, the difference between the actual number of births and the trend, summed between May 1915 (9 months after the declaration of war) and August 1919 (9 months after the armistice), yields an estimated 1.36 million children not born. This figure amounts to 3.4% of the French population in 1914 (40 million) and is comparable to the total death toll of the war for the French: 1.4 million.[5] The estimate for Germany is 3.18 million children not born. It amounts to 4.8% of the German population in 1911 (65 million) and exceeds the number of military deaths estimated at 2 million.[6] In short, the fertility reduction that occurred during World War I doubled the demographic impact of the war. Similar calculations, made by demographers, lead to comparable figures: Vincent (1946) reports a deficit of 1.6 million French births because of the war and Festy (1984) reports 1.4 million.

Was the deficit of birth during the war compensated by excess fertility after the war? To answer such question is difficult in the absence of a model of the trend in the number of births before and after the war. Vincent (1946) argues that only half of the deficit was made up for in the decade following the war. But, whether the *size* of the French population was durably affected or not by the war is a separate question from whether its *age structure* was. The answer to the latter question is a definite yes.

It is interesting to compare the fertility reduction of the war to the so-called Baby

[5]See Huber (1931, p. 413).
[6]See Huber (1931, pp. 7 and 449).

Boom. The drop in the birth rate between before the war (1913) and the trough (1916) is 50% over 3 years. The Baby Boom started in 1941, when the birth rate was 13.1 and peaked in 1947 at 21.3. The difference between the two figures is a 62% increase over 6 years. By this measure the effect of World War I, on impact, is quite large relative to that of the Baby Boom. Yet, the Baby Boom lasted longer than World War I and, therefore, its final effect on the French population is larger.

Finally, it is worth mentioning that the case of France was not unique. This already transpired in Figures 1 and 3. Figure 4 shows, in addition, the age and sex structure of the populations of Germany, Belgium, Italy as well as Europe as a whole and the United States in 1950. All European countries exhibit a deficit of births during the war which, as is the case for France, is still noticeable in the 1950 population. The United States, on the contrary, were not noticeably affected by the war. The United Kingdom appears to have experienced a reduced deficit of births during World War I compared with other European countries. Europe as a whole exhibits a noticeable deficit.

2.2 The Army

The mobilization was massive. A total of 8.5 million men served in the French army over the course of the war, while the size of the 20-50 male population is estimated at 8.7 million on January 1st 1914. On August 1st 1914, the day of the mobilization, the army counted already 1 million men. The remaining 7.5 million were called to serve throughout the four years of the war.[7]

[7] See Huber (1931, p. 89).

Not all the men serving in the army were sent to the front. On July 1st, 1915, there were 5 million men in the army but 2.3 million of them served in the rear. These men were serving in factories, public administrations and in the fields to help with the production of food for the troops and the population.[8] Between August 1914 and November 1918, the fraction of men in the army actually serving in the rear remained between 30 and 50%. The men in the rear were in touch with the civilian population and, therefore, were more likely to have the opportunities to procreate than the men at the front.

The combat troops did not spent all their time at the front either. Leaves from the front were generalized in June 1915. Starting in October 1916 soldiers at the front were granted 7 days of leave every 4 months, not including the time needed to travel back to their families. These leaves could also be augmented at the discretion of one's superior officer. These leaves augmented the physical opportunities to have children.

2.3 Women

Figure 5 shows evidence that the women reaching their childbearing years during World War I postponed their childbearing decisions. This observation is important to understand the behavior of fertility after the war. Fertility was above trend in the immediate aftermath of the war because the generation that should have given birth during the war years did so after, together with the young post-war generation. In the model of Section 3 households are allowed to chose how many children to have in 2 periods of their lives to allow this mechanism to operate and assess its importance

[8] See Huber (1931, p. 105).

for the post-war recovery of fertility.

Henry (1966) shows that the marriage market was noticeably perturbed for the generations reaching their marriage and childbearing years during World War I. Women born in 1891-1895 (aged 21 in 1914) either got married before the war or after the war. In the latter case, that is just after the war, the marriage rate of this generation was abnormally high relative to the marriage rates of other generations at the same age: a sign of "recuperation" of postponed marriages. A similar result holds true for the generation of women born in 1896-1900. By some metric, however, the perturbation of the marriage market due to World War I was "short-lived." Henry (1966) reports that the proportion of single women, at the age of 50 for the 1891-1895 generation is 12.5% and for the 1896-1900 generation it is 11.9%. These figures compare with similar figures for generations whose marriage decisions were not affected by the war such as the 1851-1855 generation: 11.2% or the 1856-1860 generation: 11.3%. Henry (1966) concludes that the replacement of the men killed during the war was done through immigration and excess marriage rates for men who did not disappear during the war years. At this stage, two observations are worth making. First, although ex-post (that is at the age of 50) the women from the 1891-1895 and 1896-1900 generations achieved the same marriage rate as the women from other generations, from the perspective of 1914, when they had to decide whether to get married and have children, the probability of keeping (or replacing) a husband must have appeared quite different to them than to the previous generations at the same age. Second, the disruption in the marriage market does not imply that births should be affected. Although it is common, it is not necessary to be married to have children. Figure 6 shows that the proportion of out-of-wedlock births increased significantly during the war. Thus it seems reasonable, as a first approximation, to study fertility choices while abstracting from the marriage market.

Little information is available on female labor during the war. There was no exhaustive census available. Some were planned during the course of the war but ended up being cancelled. Robert (2005) reports that the best information available is from seven surveys conducted by work inspectors. These surveys did not cover all branches of the economy such as railways and state-owned firms. However, data are available for 40,000 to 50,000 establishments in food, chemicals, textile, book production, clothing, leather, wood, building, metalwork, transport and commerce. These establishments employed about 1.5 million workers before the war: about a quarter of the labor force in industry and commerce. Robert (2005, Table 9.1) reports the total number employed and the number of women employed in the establishments surveyed. Although this is not the participation rate *per se* it gives a picture of female labor during the war. The share of women worker was 30% in July 1914 and peaked in January 1915 at 38.2%. It then declined slowly throughout the war and during the following years. It was 32% in July 1920. Downs (1995) and Schweitzer (2002) emphasize that the increase in women's participation during the war is moderated by the fact that most, that is between 80 and 95 percent, of the women who worked during the war also worked in more feminized sectors before the war. Downs (1995, page 48) writes

> In the popular imagination, working women had stepped from domestic obscurity to the center of production, and into the most traditionally male of industries. In truth, the war brought thousands of women from the

obscurity of ill-paid and ill-regulated works as domestic servant, weavers and dressmakers into the brief limelight of weapons production.

In the model of Section 3 a woman's labor is exogenous which, in light of the evidence just presented, is a reasonable abstraction.

2.4 Similar Episodes

Caldwell (2004) presents evidence of fertility decline for a list of thirteen social crises among which the English Civil War, the French Revolution, the American Civil War, World War I, etc... For each episode he reports significant reductions in fertility –see Table 1. He also reports that when fertility was already experiencing a declining trend, the reductions observed during the periods of unrest are significantly more pronounced than before and after. For example, the Spanish birth rate fell as much during the Civil War (1935-42) than during the 35 years before. These observations suggest that episodes of great uncertainty matter for fertility choices, even when individuals may not be physically separated.

3 The Model

3.1 The Environment

Time is discrete. There are periods of peace and one unanticipated war that lasts for a single period. The economy is populated by overlapping generations of individuals living for $I + J$ periods: I as a child and J as an adult. When an individual becomes adult it leaves the household in which it was born, and pairs with another adult of the same age and the opposite sex to form a new household of age 1. The household formation process is exogenous. Only households make decisions.

Let $m_j \in \{1, 2\}$ denote the number of adult(s) in an age-j household. It is an exogenous random variable described by a Markov chain with transition π

$$\pi(m'|m) = \text{Prob}(\{m_{j+1} = m'\}|\{m_j = m\}),$$

and initial condition $m_1 = 2$. The transition function π depends on whether the economy experiences peace or war: $\pi \in \{\pi^{\text{peace}}, \pi^{\text{war}}\}$. During peacetime the number of adults is constant:

$$\pi^{\text{peace}}(m'|m) = \mathbb{I}(\{m' = m\}).$$

During the war there is a non-zero probability that a wife remains alone after peace returns:

$$\pi^{\text{war}}(1|2) > 0.$$

The exact value of $\pi^{\text{war}}(1|2)$ is determined in Section 4.2. Since households are formed with two members and remain as such during peacetime there are no one-adult households when the war breaks out. Thus, the transition $\pi^{\text{war}}(\cdot|1)$ does not need to be specified. One can interpret $\pi^{\text{war}}(1|2)$ as the probability that a husband dies during the war and his wife does not remarry. Therefore, the probability $\pi^{\text{war}}(2|2)$ is either that of a husband surviving the war or dying but his wife re-marrying. Note that the transition function π^{war} is independent of age. This assumption is motivated by the fact that men from a large range of ages were mobilized.

A household is fecund twice during its life, at age 1 and 2. That is, it chooses how many children to give birth to only at age 1 and 2, and only if there are two adults. The number of children born to an age-1 household is denoted b_1. They remain present until the household reaches age I. The number of children born to an age-2 household is denoted b_2. They remain until it reaches age $I+1$. The stock of children present in an age-j household, denoted by n_j, is

$$n_j = b_1 \mathbb{I}\{1 \leq j \leq I\} + b_2 \mathbb{I}\{2 \leq j \leq I+1\}. \tag{1}$$

A household's preferences are represented by

$$E_1 \left\{ \sum_{j=1}^{J} \beta^{j-1} \left[U\left(\frac{c_j}{\phi(n_j, m_j)} \right) + \theta V(n_j, m_j) \right] \right\}$$

where E_1 is the expectation operator, conditional on information available at age 1. The parameter $\beta \in (0,1)$ is the subjective discount factor, c_j is total household consumption at age j and $\phi(n,m)$ is an adult-equivalent scale. The parameter θ is positive, and

$$U(x) = \frac{x^{1-\sigma}}{1-\sigma} \quad \text{and} \quad V(n,m) = (n^\rho + m^\rho)^{1/\rho}$$

with $\sigma > 0$ and $\rho \leq 1$.

At this stage a few observations are in order. First, a household values consumption per (adult equivalent) member and not total consumption. Thus, one of the costs of having a child is a reduction of consumption per (adult equivalent) member. Note also that the introduction of the adult-equivalent scale affects the way the marginal cost of a child changes when the number of adult decreases. To understand this remember that the marginal utility of consumption measures the cost of diverting resources away from consumption and into childrearing. Suppose now that an adult disappears. Then, total consumption decreases and if a household valued total consumption the marginal cost of a child would increase by a magnitude dictated by the slope of U. Since instead a household values consumption per (adult equivalent) member, this effect is mitigated by the fact that the decrease of total consumption *together* with a decrease of the number of adults implies less of a reduction of the consumption per (adult equivalent) member and, therefore, less of an increase in the marginal cost of a child. Second, children of the same age (born in the same period) and of different age (born in different periods) are perfect substitutes in utility. This assumption is made for simplicity. Third, the degree of substitutability between children and adults depends on ρ, the value of which is disciplined by data in the quantitative exercise of Section 4. When $\rho = 1$ children and adults are perfect substitutes. As ρ decreases children and adults become more complementary. In the limit, as $\rho \to -\infty$, children and adults are perfect complement. The value of ρ is important for the effect of an exogenous shock to the number of adults, m, on fertility. If children and adults are perfect substitute, a decrease of the number of adults can be compensated by an increase in fertility, holding everything else constant. If, however, children and adults are complement, a decrease of the number of adults implies a reduction of the optimal number of children. Fourth, the number of adults acts as a preference shock through two channels: (i) a decrease of the number of adults directly affects utility and, in particular, it reduces the marginal utility of children through V; (ii) a decrease of the number of adults implies an increase in consumption per (adult equivalent) member, holding everything else constant. Beside the effect of m on preferences, a decrease of the number of adults also acts as an income shock. This is described in what follows.

Adults are endowed with one unit of productive time per period. A husband supplies his time inelastically while a wife allocates hers between raising children and working. A child requires τ units of a wife's time and e units of the consumption good for each period during which it is present in the household. The parameter τ represents the state of the "childrearing" technology and, therefore, is not a control variable. Thus, a wife's time allocation is indirectly controlled through the number of children she gives birth to. The wage rate for a husband is denoted by w^m and is assumed to grow at the constant (gross) rate $g > 1$ per period. The wage rate for a wife is denoted w^f and is assumed to grow at rate g too. Let $\mathbf{w}$ denote the vector of wages: $\mathbf{w} = \left(w^m, w^f\right)$. It is convenient to define the function

$$L(\mathbf{w}, m) = \begin{cases} w^m + w^f & \text{when } m = 2 \\ w^f & \text{when } m = 1 \end{cases}$$

as the "potential" labor income of a household, i.e., the labor income it would receive if no time was devoted to raising children. The actual labor income of a household with m adults, n children and facing wages $\mathbf{w}$ is then $L(\mathbf{w}, m) - \tau w^f n$. A household has access to a one-period, risk-free bond with (gross) rate of interest $1/\beta$. It can freely borrow and lend any amount at this rate. It owns no assets at the beginning of age 1.

3.2 Optimization

Let $\mathbf{s} = (\mathbf{w}, \pi)$ describe the aggregate state of the economy, that is the vector of wages as well as the transition function for m. At the beginning of age 1 a household is made of 2 adults. It has no assets and no children. It decides to consume (c) save (a') and how many children to give birth to (b_1). Its value function when facing the state $\mathbf{s}$ is

$$W_1(\mathbf{s}) = \max_{c, b_1, a'} U\left(\frac{c}{\phi(b_1, 2)}\right) + \theta V(b_1, 2) + \beta \sum_{m'=1,2} W_2(a', m', b_1, \mathbf{s}') \pi(m'|2) \quad (2)$$

subject to

$$c + a' + b_1 \left(e + \tau w^f\right) = L(\mathbf{w}, 2) \quad (3)$$

and

$$\mathbf{s}' = \left((g w^m, g w^f), \pi^{\text{peace}}\right). \quad (4)$$

The right-hand side of the budget constraint (3) shows the "potential" labor income of a household. The time cost of raising b_1 children appears as an expenditure on the left-hand side: $\tau w^f b_1$. Thus, the effective labor income is, as discussed earlier, $w^m + w^f(1 - \tau b_1)$. The function $W_2(a', m', b_1, \mathbf{s}')$ is the value function of a household of age 2 with a' assets accumulated, b_1 children born at age 1, m' surviving adults, and facing the aggregate state $\mathbf{s}'$. Note that at age 1 the number of children born and the number of children present in the household are the same since $n_1 = b_1$, as per Equation (1). Note, finally, that b_1 is a relevant state variable for an age 2 household whenever $I \geq 2$ as assumed here.

Equation (4) is the law of motion for the aggregate state. A few points are worth mentioning. First, a household anticipates wages to grow at the constant rate g. Second it expects peace to prevail in the next period. This assumption is made for simplicity. It implies that the war is unanticipated since during peacetime a household expects the next period to be one of peace too. It also implies that once the war breaks out, a household expects it to be over by the end of the period.

At the beginning of age 2 a household learns its number of adults, m, and decides to consume (c) save (a') and how many children to give birth to (b_2). The optimization problem writes

$$W_2\left(a, m, b_1, \mathbf{s}\right) = \max_{c, b_2, a'} U\left(\frac{c}{\phi(b_1 + b_2, m)}\right) + \theta V(b_1 + b_2, m) + \beta \sum_{m'=1,2} W_3(a', m', b_1, b_2, \mathbf{s}')\pi(m'|m) \quad (5)$$

subject to

$$\begin{aligned} c + a' + (b_1 + b_2)\left(e + \tau w^f\right) &= L(\mathbf{w}, m) + \frac{a}{\beta} \\ \mathbf{s}' &= \left((gw^m, gw^f), \pi^{\text{peace}}\right) \end{aligned} \quad (6)$$

and the solution for b_2 is zero whenever $m = 1$. The right-hand side of the budget constraint represents total income: the sum of "potential" labor income as well as income from assets accumulated during the previous period. The time cost of raising the children present in the household at age 2 appears as an expenditure on the left-hand side. As per Equation (1) the number of children present in the household at age 2 is $n_2 = b_1 + b_2$. The function $W_3(a', m', b_1, b_2, \mathbf{s}')$ is the value function of an age 3 household with a' assets accumulated, m' adults, b_1 children born at age 1, b_2 children born at age 2 and facing the state $\mathbf{s}'$. Note that, even though there are no births after age 2, the household must keep track of the number of children born at age 1 and 2 in order to assess the childrearing cost it is facing each period, as well as to compute its (adult equivalent) size.

From age 3 onward the only choices are consumption (c) and savings (a'). The number of children, n_j, evolves in line with the law of motion described by Equation (1). Formally, the optimization problem writes

$$\begin{aligned} W_j(a,m,b_1,b_2,\mathbf{s}) = \max_{c,a'} \; & U\left(\frac{c}{\phi(n,m)}\right) + \theta V(n,m) \\ & + \beta \sum_{m'=1,2} W_{j+1}(a',m',b_1,b_2,\mathbf{s}')\pi(m'|m) \end{aligned} \tag{7}$$

subject to

$$\begin{aligned} c + a' + n\left(e + \tau w^f\right) &= L(\mathbf{w},m) + \frac{a}{\beta} \\ \mathbf{s}' &= \left((gw^m, gw^f), \pi^{\text{peace}}\right) \\ n &: \text{given by Equation (1)} \\ j &> 2 \end{aligned} \tag{8}$$

and $a' = 0$ when $j = J$.

3.2.1 Optimality Conditions

The first order conditions for consumption and savings at age 1 imply the Euler equation:

$$U'\left(\frac{c}{\phi(b_1,2)}\right)\frac{1}{\phi(b_1,2)} = \beta \sum_{m'=1,2} \frac{\partial}{\partial a'} W_2(a',m',b_1,\mathbf{s}')\pi(m'|2). \tag{9}$$

Note that the marginal cost of a reduction in household consumption, measured on the left-hand side, is the marginal utility of consumption per (adult equivalent) member. The marginal benefit is the expected marginal gain at age 2, measured on the right-hand side of the equation. The first order condition for consumption and fertility can be rearranged into

$$\begin{aligned}\theta\frac{\partial}{\partial b_1}V(b_1,2) + \beta \sum_{m'=1,2} \frac{\partial}{\partial b_1} W_2(a',m',b_1,\mathbf{s}')\pi(m'|2) = \\ U'\left(\frac{c}{\phi(b_1,2)}\right)\frac{1}{\phi(b_1,2)}\left(e+\tau w^f + \frac{c}{\phi(b_1,2)}\frac{\partial}{\partial b_1}\phi_1(b_1,2)\right)\end{aligned} \tag{10}$$

where the left-hand side is the marginal benefit of a child born at age 1, and the right-hand side is the marginal cost. The marginal benefit comprises two parts: the instantaneous benefit at age 1, measured by $\theta\partial V(b_1,2)/\partial b_1$, and the expected marginal benefit from age 2 onward measured by $\beta\sum_{m'=1,2}\partial W_2(a',m',b_1,\mathbf{s}')/\partial b_1 \times \pi(m'|2)$. The marginal cost comprises three elements. The first two are the resource cost of raising the child, e, and the time cost, i.e., the loss of a fraction of the wife's labor income, τw^f. The third element is the allocation of consumption to the newborn. The new child represents an increase of $\partial\phi(b_1,2)/\partial b_1$ adult-equivalent, thus it receives $c/\phi(b_1, 2) \times \partial\phi(b_1, 2)/\partial b_1$ units of consumption. These three costs, expressed in consumption units, are weighted by the marginal utility of consumption per (adult equivalent) member, $U'(c/\phi(b_1, 2))/\phi(b_1, 2)$.

There are two mechanisms through which the war affects fertility, the second magnifying the effect of the first. First, the expected marginal benefit of a child (left-hand side of 10) decreases during the war. This is because the war implies a reduction of the expected number of adults from 2 to $2 - \pi(1|2)$, and because the marginal utility of a child is increasing in the number of adults: $V_{nm} > 0$. The second reason why the war reduces optimal fertility is because it also implies an increase of the marginal cost of raising a child. This increase occurs because consumption decreases during the war and, therefore, its marginal utility increases, i.e. the cost of diverting resources away from consumption and toward raising a child increases. The decrease in consumption is the result of three separate causes: (i) a contemporaneous loss of income due to the mobilization of the husband, i.e. a temporary decrease of w^m; (ii) an increase in savings due to the decrease in future expected income, i.e. an expected reduction in the number of adults; and (iii) an increase in savings due to increased risk with respect to m.

At age 2 the Euler Equation and optimality condition for fertility are:

$$U'\left(\frac{c}{\phi(b_1 + b_2, m)}\right)\frac{1}{\phi(b_1 + b_2, m)} = \beta \sum_{m'=1,2} \frac{\partial}{\partial a'} W_3(a', m', b_1, b_2, \mathbf{s}')\pi(m'|m) \qquad (11)$$

and

$$\theta \frac{\partial}{\partial b_2} V(b_1 + b_2, m) + \beta \sum_{m'=1,2} \frac{\partial}{\partial b_2} W_3(a', m', b_1, b_2, \mathbf{s}')\pi(m'|m) =$$
$$U'\left(\frac{c}{\phi(b_1 + b_2, m)}\right) \frac{1}{\phi(b_1 + b_2, m)} \left(e + \tau w^f + \frac{c}{\phi(b_1 + b_2, m)} \frac{\partial}{\partial b_2} \phi(b_1 + b_2, m)\right) \quad (12)$$

which have the same interpretations as Equations (9) and (10). When $m = 1$ a household cannot have children, therefore $b_2 = 0$ and Equation (12) does not hold with equality.

At age 3 and above the only choice faced by a household is that of consumption and savings. The optimality conditions for consumption and savings are then summarized by the Euler equation

$$U\left(\frac{c}{\phi(n, m)}\right) \frac{1}{\phi(n, m)} = \beta \sum_{m'=1,2} \frac{\partial}{\partial a'} W_{j+1}(a', m', b_1, b_2, \mathbf{s}')\pi(m'|m).$$

4 Quantitative Analysis

In this section I calibrate the model to fit the time series of the French fertility rate from 1800 until the eve of World War I. Using the calibrated parameters I conduct a set of three experiments where I compute the optimal decisions of the generations reaching their childbearing years during the war and after. In the first experiment, which I refer to as the "baseline," the generations reaching their childbearing years during the war experience two shocks that their predecessors did not: a higher risk that a wife remains alone in the household after the end of the war, and a partially-compensated loss of a husband's income during the war. This experiment provides a quantitative assessment of the effect of the war on optimal fertility. Then, I conduct two counterfactual experiments to decompose the contribution of the shocks. In the first, I report the optimal fertility implied by the model when abstracting from the income loss during the war while maintaining the increased risk that a wife remains alone. In the second I report the results of the opposite exercise: the optimal fertility predicted by the model when a household faces an income loss during the war, but not the risk that a wife remains alone. Finally, I also discuss the sensitivity of the baseline results with respect to the choice of some parameters.

4.1 Calibration

A model period is 5 years. Thus, an individual of age 1 in the model can be interpreted as a child between the age of 0 and 5 in the data. Let $I = 4$ and $J = 7$ so that an individual remains in the household in which it was born until it reaches the age of 15-20, and a young household is composed of two individuals between the age of 20 and 25. Households in the model have their children during the first and second period of their adult lives, which correspond to their 20s in the data. Life ends between the age of 50 and 55. An optimal path of fertility is a vector of 26 observations corresponding the the calendar years $1806, 1811, \ldots, 1931$.

Let the rate of interest on the risk free asset be 4 percent per year. This implies a subjective discount factor $\beta = 1.04^{-5}$. I assume that w^m and w^f grow at the same, constant (gross) rate g from some initial conditions. I use the rate of growth of the Gross National Product per capita, 1.6 percent per year, to calibrate g –see Carré et al. (1976, Tables 1.1 and 2.3). Thus, $g = 1.016^5$. I normalize the initial condition (corresponding to 1806 in the data) for w^m to 1 and I assume a constant gender gap in wages w^f/w^m. Huber (1931, pp. 932-935) reports figures for the daily wages for men and women in agriculture, industry and commerce in 1913. In industry, a woman's wage in 1913 was 52% of a man's. In agriculture the gap was 64%, and in commerce it was 77%. Since commerce was noticeably smaller than agriculture and industry I use $w^f/w^m = 0.6$. In Section 4.4 I present sensitivity results with respect to w^f/w^m. Note that a gender gap in earnings of 60% is consistent with the findings of the more recent literature studying the United States. Blau and Kahn (2006, Figure 2.1) report that women working full-time earned between 55% and 65% of what men earned from the 1950s to the 1980s. Knowles (2010) reports that, throughout the 1960s, the ratio of mean wages of women to those of men was slightly below 60% in the U.S.

For ϕ, the adult-equivalent scale, I use the "OECD-modified equivalence scale" which assigns a value of 1 to the first adult member in a household, 0.5 to the second adult and 0.3 to each child:

$$\phi(n, m) = \frac{1}{2} + \frac{m}{2} + 0.3n.$$

In the model the war breaks out in 1916. The 1911 generation gives birth to children in 1911 and 1916. It is then affected by the war, which I assume to be unanticipated, only in 1916. Thus, I calibrate the remaining parameters to minimize the distance between the fertility data up to and including 1911 and the fertility predicted by the model, assuming that $\pi = \pi^{\text{peace}}$ for all generations.

More specifically, let $\alpha = (\sigma, \theta, \rho, \tau)'$ be the vector of remaining parameters where the first three elements are preference parameters and τ is the time-cost of a child. They are chosen in order to solve the following minimization problem:

$$\min_{\alpha} \sum_{t \in \mathcal{I}} (f_t(\alpha) - \mathbf{f}_t)^2 + (\tau \times n_{1911}(\alpha) - 0.1)^2 \tag{13}$$

where $\mathcal{I}$ is an index set: $\mathcal{I} = \{1806, 1811, 1816, \ldots, 1911\}$. This objective function deserves a few comments. First, $f_t(\alpha)$ is the fertility rate implied by the model for a given value of α. Since women in households of age 1 and 2 give births at each date, $f_t(\alpha)$ is the sum of births from these two generations at date t, divided by 2. Second, $\mathbf{f}_t$ is the empirical counterpart of $f_t(\alpha)$. It is constructed from birth rates from Mitchell (1998) as well as fertility data from the French National Institute for Statistics and Economic Studies (Insee). The birth rate, that is the number of birth per population is a different measure of fertility than the fertility rate which is the number of birth per fertile women. The latter is the empirical counterpart of the decisions of households of age 1 and 2 in the model. The French fertility rate, unfortunately, is not available before 1900 while Mitchell's data goes back to 1800. After splicing the two series together in 1900, however, one can verify that their behavior is quite close on the period over which they overlap.[9] Third, $n_{1906}(\alpha)$ is the total number of children born to the 1906 generation. Thus, the second part of the objective function is the distance between the time spent by this generation raising its children and its empirical counterpart, 10%. The latter figure comes from Aguiar and Hurst (2007, Table II). They report that in the 1960s a woman in the U.S. spends close to 6 hours per week on various aspect of childcare, that is primary, educational and recreational. This amounts to 10% of the sum of market work, non-market work

[9]Data available upon request.

and childcare (61 hours). Thus, τ is set to imply that the time spent by a women on childcare, on the eve of the war, is 10% as well. The good cost of raising a child is assumed to be zero, i.e., $e = 0$. Note that if e was proportional to w^f that is, if the good cost of raising a child was growing at rate g, then setting e to 0 would be innocuous since e could be subsumed into τ. In Section 4.4 I present sensitivity results with respect to the target figure for the time cost of raising a child.

Although σ, θ, ρ and τ are determined simultaneously, some aspects of the data are more important than others for some parameters. The level of fertility, in particular, is critical to discipline the parameter θ which measures the intensity of a household's taste for children. The time cost of a child, that is 10% of a woman's time, is critical in determining the value of τ. The parameter σ determines the curvature of the marginal utility of consumption and, since the number of adults in a household in constant, the parameter ρ determines the curvature of the marginal utility of fertility. Thus the decline in fertility which results from a comparison between its marginal cost (partly driven by the marginal utility of consumption) and its marginal benefit, disciplines the parameters ρ and σ.

The calibrated parameters are displayed in Table 2. Figure 7 displays the computed and actual fertility rate for the pre-war period. The model fits the data well. It generates a downward trend in the birth rate due to the rising opportunity cost of raising children when the wage rate increases.

4.2 Baseline Experiment

In the model the war breaks out in 1916. It is unanticipated, and it is expected to last for one period. Using the calibrated parameters, I compute the optimal fertility of the households of age 1 and 2 in 1916. Unlike their predecessors, they use the transition π^{war} to assess the risk that their wives remain alone after the war is over, and they also face a temporary loss of their husbands' income during the war. Thus, the aggregate state of the economy is described by

$$\mathbf{s}_{1916} = \left(\left((1-\delta)\, w^m_{1916}, w^f_{1916}\right), \pi^{\text{war}}\right).$$

where δ is the fraction of a husband's income that is lost because of the war. The wages w^m_{1916} and w^f_{1916} are defined by the initial conditions and rate of growth determined in Section 4.1. An age 2 household in 1916 inherits its individual state variables from decisions made in 1911, when it was of age 1 and used the transition function π^{peace} to make its decisions: savings and age-1 fertility.

I calibrate $\pi^{\text{war}}(1|2)$ as

$$\pi^{\text{war}}(1|2) = \frac{\text{military losses of World War I}}{\text{total men mobilized}}.$$

The military losses where 1.4 millions while 8.5 million men were mobilized. Thus, I use $\pi^{\text{war}}(1|2) = 1.4/8.5 = 0.16$. This figure is not perfect. On the one hand it might exaggerate the risk from the perspective of a wife since she has the possibility of remarrying after the war if her husband died. This possibility would allow a wife to raise her children with hers and another husband's income. On the other hand the probability may underestimate the risk since the husband may survive the war but come home disabled. In the case of World War I this was a distinct possibility since the massive use of artillery and gases made this conflict quite different from any other conflict before. Huber (1931, p. 448) reports 4.2 million wounded during the war: half of the men mobilized. The number of invalid was 1.1 million among which 130,000 were mutilated and 60,000 were amputated. In Section 4.4 I present sensitivity results with respect to $\pi^{\text{war}}(1|2)$ to address these concerns.

Households did not get fully compensated for the income loss they incurred while the men were mobilized. Downs (1995) cites a compensation amounting to somewhere between 35 and 60% of a man's pre-war salary in agriculture or industry.[10] To represent this loss, I set $\delta = 0.5$. In Section 4.4 I present sensitivity results with respect to the magnitude of the income loss of the husband.

Figure 8 and Table 3 show the results of the experiment. The fertility rate falls by 66% in 1916 relative to 1911 in the model, versus 49% in the data. Thus the model over-predicts the decline in fertility by 34% (66/49 = 1.34). After the war fertility increases by 248% in the model versus 118% in the data. Thus the model over-predicts the post-war increase by 110% (248/118 = 2.1). Figure 9 helps interpreting these results. It shows the fertility by age at different point in time, as predicted by the model. Observe that the fertility drop of the war is a combination of a decline of fertility for both the age 1 and age 2 households. These households face an increased risk that their wives remain alone after the war, which implies a loss of expected income. In addition they face a reduction in their contemporaneous income. These

[10]See Downs (1995, p. 49) and Huber (1931, pp. 932-935).

shocks lead them to reduce their consumption, thereby increasing the cost of raising children. The increase of fertility after the war is a consequence of the intertemporal reallocation of births by the 1916 generation. This generation reduces its fertility during the war, when it is of age 1, and increases it above trend once the war is over, when it is of age 2. So the age at birth for this generation has increased. A fact consistent with the pattern observed in the data of figure 5. Finally the young households of 1921, the first post-war generation in the model, do not face the risk and income loss faced by the 1916 generation. Hence they do not need to lower their consumption and, therefore, they face a lower cost of raising children. So, this generation has an age-1 fertility that is consistent with the trend that prevailed before the war broke out.[11]

This exercise shows that the combination of a husband's mobilization, i.e., his inability to earn income during the war, and the likelihood that his wife might remain alone after the war imply large changes in optimal fertility, over-predicting both the decrease observed during the war and the catch-up observed after. Note again that although, in the model, husbands are unable to receive income during the war, there are no physical separations of couples.

[11]Since actual fertility is below the trend predicted by the model in 1911, another way to assess the result of the experiment is to compare deviations from trend in the data and the model. The trend of fertility is the path implied by the model in the absence of the war. The data shows that fertility declined 53% below its trend in 1916 while the model predicts a 65% decline. By this measure the model over-predicts the decline in fertility by 22% (65/53 = 1.22). Similarly, the model over-predicts the increase after the war: the data shows a 4% deviation from trend while the model predicts a 25% deviation.

4.3 Decomposition

To evaluate the relative contributions of the shocks faced by households exposed to the war during their fertile years, I conduct two counterfactual experiments. In the first, I recompute the optimal fertility path assuming that $\delta = 0$, while maintaining $\pi^{\text{war}}(1|2) = 1.4/8.5 = 0.16$, i.e., the only shock faced by households during the war is the change to the transition function governing the number of adults. In the second experiment I maintain $\delta = 0.5$ while imposing $\pi^{\text{war}}(1|2) = 0$. Thus, the only shock faced by households is a reduction of their contemporaneous income.

Figure 10 and Table 3 show the results of the experiments. When households are faced with the same risk of loosing their husbands as in the baseline, but no contemporaneous income loss, the decrease of fertility is 83% of what the baseline predicted. The post-war increase is 72% of the baseline prediction. This result suggests that the bulk of the fertility changes caused by the war can be attributed to the increased risk, that households faced, to see their husbands not return (or not be replaced) after the war.

Indeed, when the only shock faced by households is the loss of income due to the mobilization, the fertility decline is 25% of the baseline's prediction and the post-war increase 8 percent. This result implies that if households anticipated to replace deceased husbands for sure, then the decline in optimal fertility should have been 32% of the actual decline ($16/49 = 0.32$, see Table 3.)

It is not surprising that the risk that a wife remains alone plays a larger role than the contemporaneous income loss for a household. The latter is a temporary shock while the former is a permanent income shock. But, in addition to being an income shock, a reduction of the number of adults is also a preference shock, as discussed in Section 3.1, which reduces the expected marginal benefit for a child.

4.4 Sensitivity

I consider alternative values for (i) the probability that a woman remains alone after the war, $\pi^{\text{war}}(1|2)$; (ii) the magnitude of the husband's income loss during the war, δ; (iii) the time cost of raising children, τ; and (iv) the gender wage gap in earnings, w^f/w^m.

a - Sensitivity to $\pi^{war}(1|2)$, the Risk that a Wife Remains Alone after World War I

Consider two alternative values for $\pi^{\text{war}}(1|2)$, the probability that a woman remains alone after the war. The first is $\pi^{\text{war}}(1|2) = 0.1$ instead of 0.16 in the baseline. The second is $\pi^{\text{war}}(1|2) = 0.2$. In both cases the baseline experiment of Section 4.2 is performed with the new value of $\pi^{\text{war}}(1|2)$. Table 4 reports the results. It transpires that this probability matters noticeably for the results of the exercise but that, even in the conservative case where the risk for a wife to remain alone is 10%, the model still over-predicts the decline in fertility by 10% (v. 34% in the baseline) and the post-war increase by 31% (v. 110% in the baseline).

b - Sensitivity to δ, the Income Loss of a Husband During World War I

In the experiment of Section 4.2 a household loses 50% of a husband's income because of mobilization. I consider two alternative values: one where the loss of income is 25% and one where it is 75%. Performing the same experiment as in Section 4.2

with these values implies results that are reported in Table 5. As the income loss gets smaller, the model accounts for a smaller proportion of the actual decline and post-war increase. In the case of an income loss of 25% during the war, the model over-predicts the decline in fertility by 23% (v. 34% in the baseline). When the income loss is 75% the model over-predicts the decline in fertility by 42%

Note that lower values of δ and $\pi^{\text{war}}(1|2)$ imply a smaller effect of the war than in the baseline. A combination of these lower parameters can then deliver a model's prediction that is close to the data. In fact, when $\delta = 0.25$ and $\pi^{\text{war}}(1|2) = 0.1$, the model predicts a 48% drop in fertility during the war (v. 49 in the data) and a 118% increase after the war (v. 118 in the data).

c - Sensitivity to the Time Cost of Raising a Child

Consider now alternative targets for the time cost of raising children. For each new value the model needs to be calibrated again, in exactly the same fashion as in Section 4.1 with the exception of the target in the second component of the objective function (13). Then the experiment of Section 4.2 is performed. I consider two alternative targets: a time cost of 5% and a time cost of 20%. The results are displayed in Table 6. There are two observations worth making here. First, the model over-predicts changes in fertility in both cases. Second, the model's prediction for the change in fertility is not monotonic in the time cost of a child. It may appear "counter-intuitive" that the effect of the war on fertility is not exacerbated when the cost of a child is larger than in the baseline, e.g., when it is 20%. The reason for this result is that, as the target figure for the time cost of a child changes, other parameters change too. In particular, a larger-than-baseline time cost of raising a child implies, through the calibration procedure, a higher value for ρ. This can be understood as follows: as the opportunity cost of raising a child increases the marginal cost increases too. Since the model is calibrated to fit the data, marginal cost and marginal benefit must be equalized at the same fertility level. This implies that the marginal benefit of a child must also increase, which is achieve through higher values for ρ and θ. Higher values for ρ, however, imply less complementarity between adults and children in utility. This, in turn, makes the war less costly.

Another experiment with respect to the time cost of children consists in changing τ without recalibrating the model. In this case the time series of fertility does not fit the data, but conclusions can be drawn from the change in fertility during the war. In the case where τ is divided by two relative to its baseline value, the change in fertility during the war is 123% of the data (v. 134 in the baseline), and the increase after the war is 162% of the data (v. 210 in the baseline). If τ is set at twice its baseline value the model accounts for 144% and 274% of the changes in fertility during and after the war. Thus, the effect of the war is indeed increasing in the time cost of raising a child. However, even with a time cost parameter twice as little as in the baseline calibration the model still over-predicts the changes in fertility caused by the war.

d - Sensitivity to w^f/w^m, the Gender Earning Gap

In Table 7 I report the results of an exercise where I perform a sensitivity analysis with respect to w^m/w^f, the gender earning gap. I consider two alternative values: 40 and 80%. As for the sensitivity analysis with respect to τ, the model's paramaters are calibrated again for each alternative value of w^m/w^f and the experiment of Section 4.2 is performed. The model over-predicts fertility changes in all these experiments.

5 Conclusion

The human losses of World War I were not only on the battlefield. In France, the number of children not born during the war was as large as military casualties (larger in the case of Germany). The age structure of population in France and other European countries was significantly changed by this event, and the effect lasted for the entire twentieth century. In this paper I argue that this phenomenon is more than accounted for by the optimal decisions of households facing two shocks: a loss of income during the war due to the mobilization of men, and an increased risk that women remain alone after the war. These two shocks imply that young adults during the war see their contemporaneous and expected income decline. As a result they save more and consume less which increases the cost of having children. The resulting drop in fertility is 34% larger than the actual decline. The model is also able to generate the strong catch-up of fertility after the war, mostly because of the intertemporal reallocation of births done by the young generations during the war. The physical separation of couples which is often cited to explain the fertility decline during the war may have been a factor of secondary importance. This finding is consistent with a general pattern exhibited by fertility, across countries and over time, i.e., it tends to decline during periods of significant unrest even though there may be no physical separations of couples.

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Table 1: Changes in Fertility for Countries Experiencing Major Social Upheavals

Country	Episode	Period	Change in CBR (%)
England	Civil War, Commonwealth,		
	and early Restoration	1641-66	−17.3
France	Revolution	1787-1804	−22.5
USA	Civil War	1860-70	−12.8
Russia	WWI and Revolution	1913-21	−24.4
Germany	War, revolution, defeat, inflation	1913-1924	−26.1
Austria	War, defeat, empire dismembered	1913-24	−26.9
Spain	Civil war and dictatorship	1935-42	−21.4
Germany	War, defeat, occupation	1938-50	−17.3
Japan	War, defeat, occupation	1940-55	−34.0
Chile	Military coup and dictatorship	1972-78	−22.3
Portugal	Revolution	1973-85	−33.3
Spain	Dictatorship to democracy	1976-85	−37.2
Eastern Europe	Communism to capitalism	1986-98	
	Russia		−56.0
	Poland		−40.0
	Czechoslovakia (Czech Republic)		−38.0

Source: Caldwell (2004, Table 1).

Note: CBR is Crude Birth Rate.

Table 2: Calibration

Preferences	$\beta = 1.04^{-5}$, $\theta = 0.62$, $\rho = -0.10$, $\sigma = 0.86$
Wages	$w^m = 1, w^f = 0.6$ for initial (1806) generation
	$g = 1.016^5$
Cost of children	$\tau = 3.65$, $e = 0$
Adult equivalent scale	$\phi(n, m) = 1/2 + m/2 + 0.3n$
Demography	$I = 4$, $J = 7$

Table 3: Results

	Decrease (%)	Increase (%)
Data	49	118
Baseline	66	248
Baseline / Data	1.34	2.10
Experiment 1 (no income loss)	55	153
Experiment 1/Baseline	0.83	0.72
Experiment 2 (no risk)	16	20
Experiment 2/Baseline	0.24	0.08

Note: The table shows the decline in fertility between 1911 and 1916, in percentage, as well as the increase between 1916 and 1921.

Table 4: Sensitivity to $\pi^{\text{war}}(1|2)$, the Risk that a Wife Remains Alone in her Household after World War I

	%age of decline	%age of increase
$\pi^{\text{war}}(1|2) = 0.10$	110	131
$\pi^{\text{war}}(1|2) = 0.16$ (Baseline)	134	210
$\pi^{\text{war}}(1|2) = 0.20$	142	252

Note: The first column reports the percentage of the fertility decline during the war that is accounted for in the experiment. The second column reports the percentage of the fertility increase after the war that is accounted for.

Table 5: Sensitivity to δ, the Income Loss of a Husband During World War I

	%age of decline	%age of increase
$\delta = 25\%$	123	166
$\delta = 50\%$ (Baseline)	134	210
$\delta = 75\%$	143	266

Note: The first column reports the percentage of the fertility decline during the war that is accounted for in the experiment. The second column reports the percentage of the fertility increase after the war that is accounted for.

Table 6: Sensitivity to the Time Cost of Raising a Child

Time cost	%age of decline	%age of increase
5%	132	199
10% (Baseline)	134	210
20%	118	147

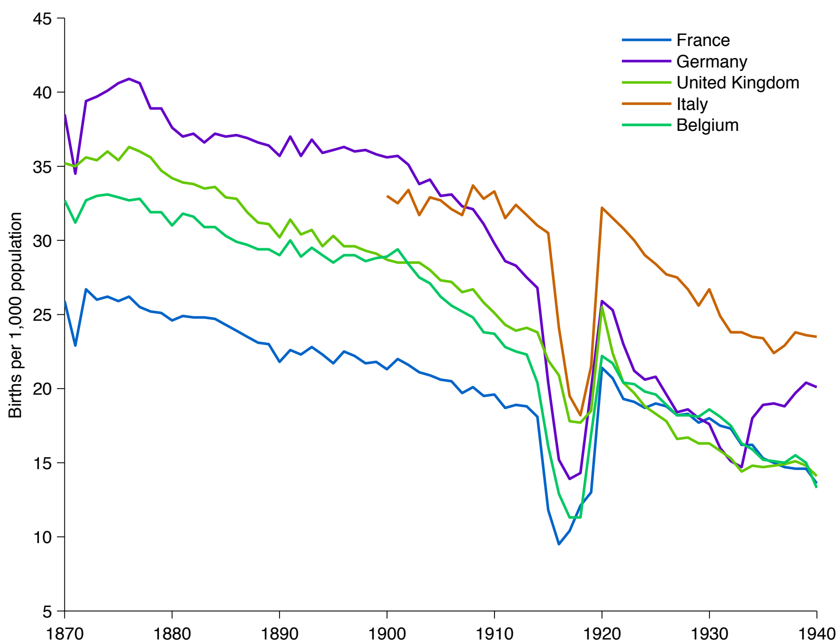
Note: The first column reports the percentage of the fertility decline during the war that is accounted for in the experiment. The second column reports the percentage of the fertility increase after the war that is accounted for.

Table 7: Sensitivity to w^f/w^m, the Gender Earning Gap

	%age of decline	%age of increase
$w^f/w^m = 0.4$	155	362
$w^f/w^m = 0.6$ (baseline)	134	210
$w^f/w^m = 0.8$	118	172

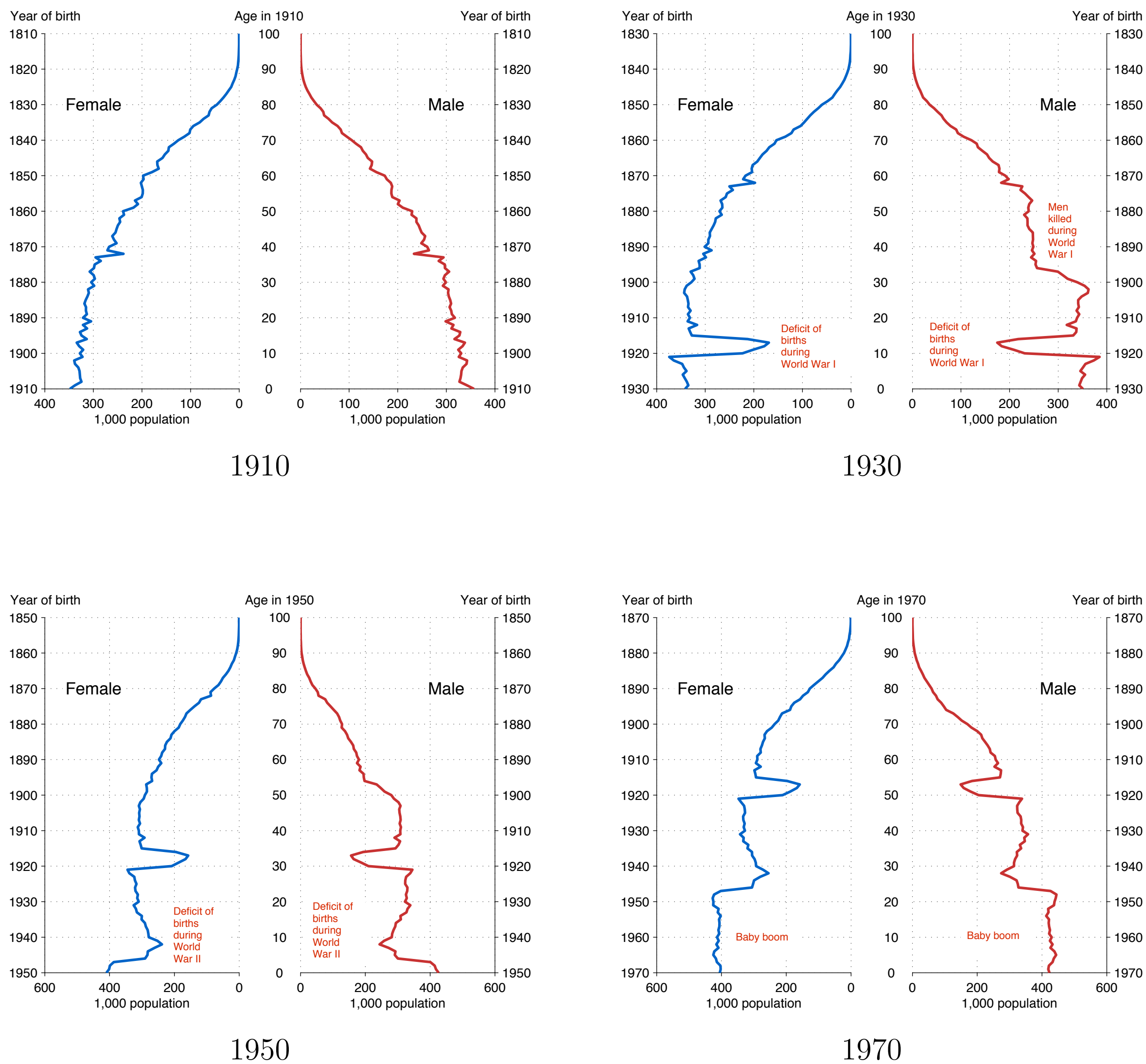
Note: The first column reports the percentage of the fertility decline during the war that is accounted for in the experiment. The second column reports the percentage of the fertility increase after the war that is accounted for.

Figure 1: Birth Rates in Some European Countries



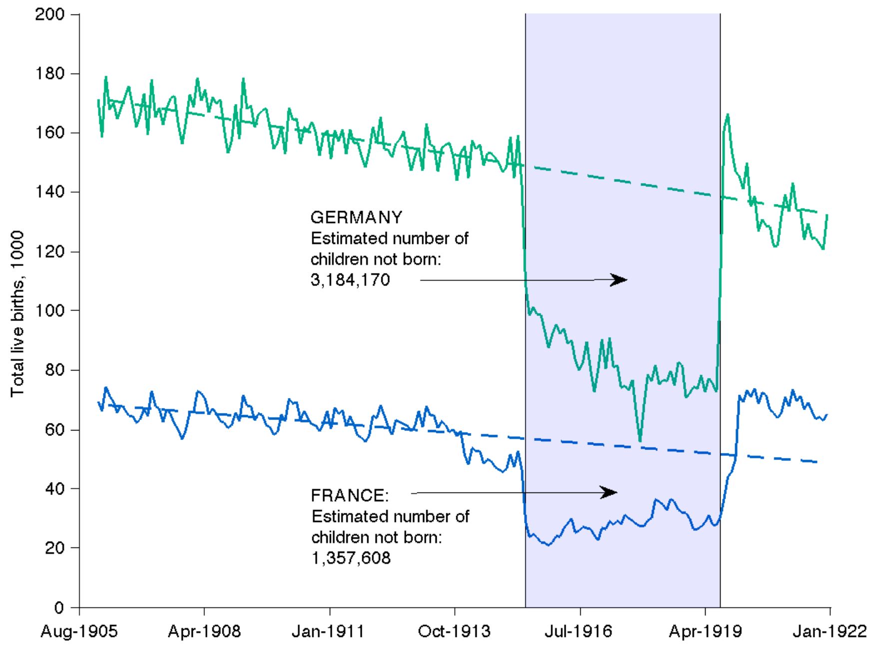
Source: Mitchell (1998).

Figure 2: French Population by Age and Sex, January 1, Selected Years



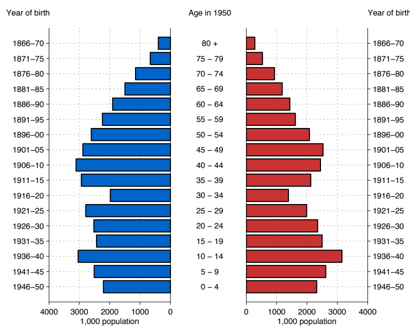
Source: Insee, état civil et recensement de population.

Figure 3: Number of Births per Month in France and Germany

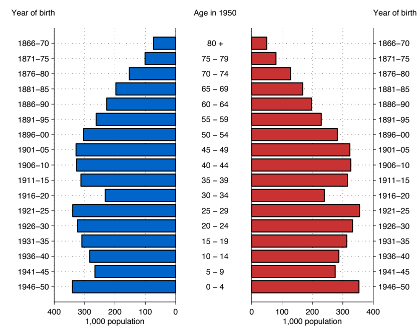


Note: The source of data is Bunle (1954, Table XI). The linear trends are estimated using the data from January 1906 until July 1914. The shaded area is from May 1915, that is 9 months after the declaration of War between France and Germany in August 1914, until August 1919 that is 9 months after the armistice was signed in November 1918.

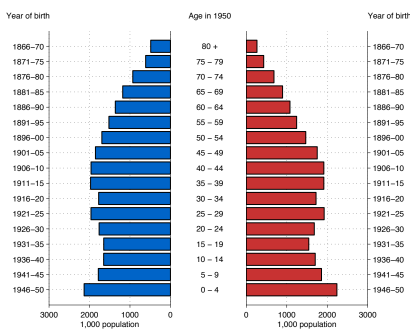
Figure 4: Population by Age and Sex, Selected Countries, 1950



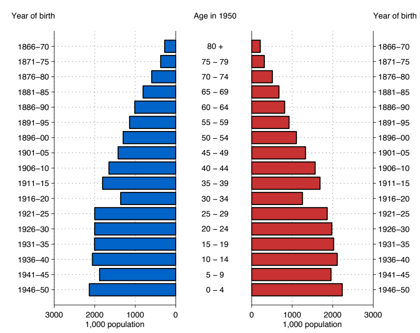
Germany



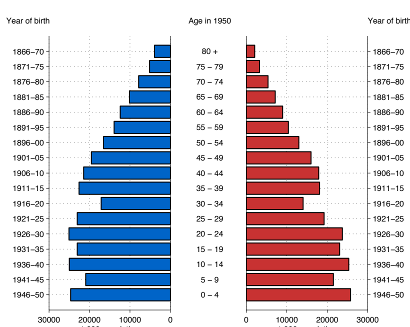
Belgium



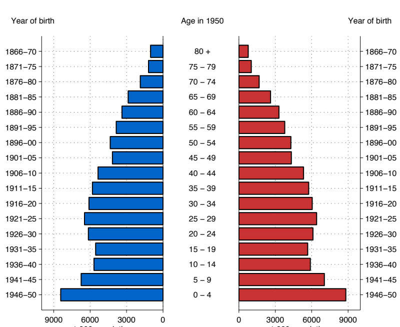
United Kingdom



Italy



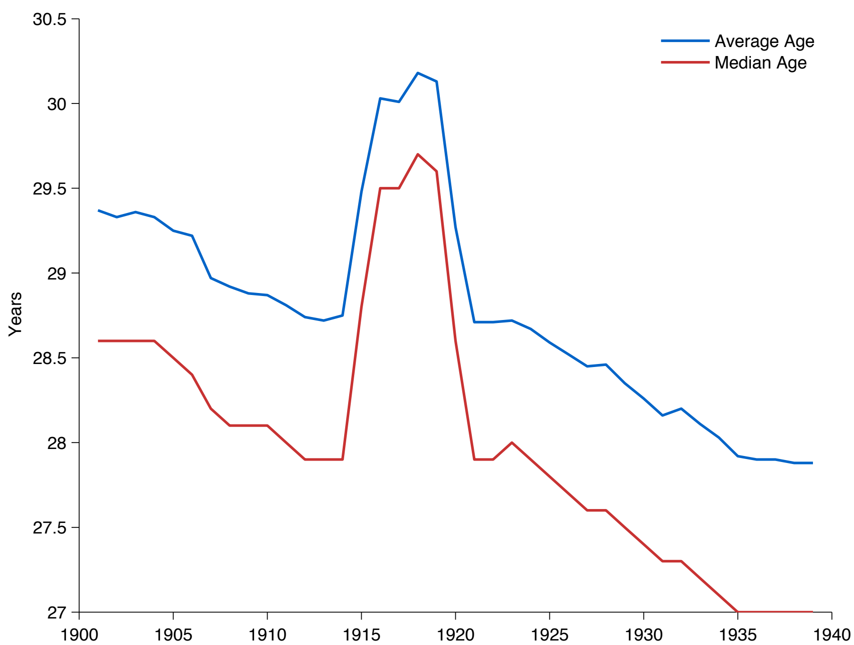
Europe



United States

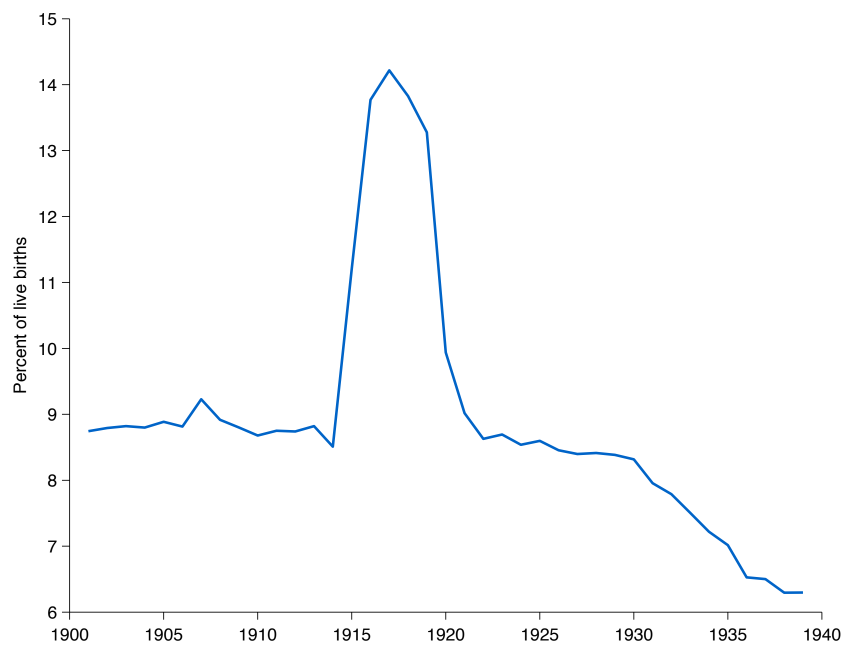
Source: United Nations, Department of Economic and Social Affairs, Population Division.

Figure 5: Average and Median Age at Birth in France



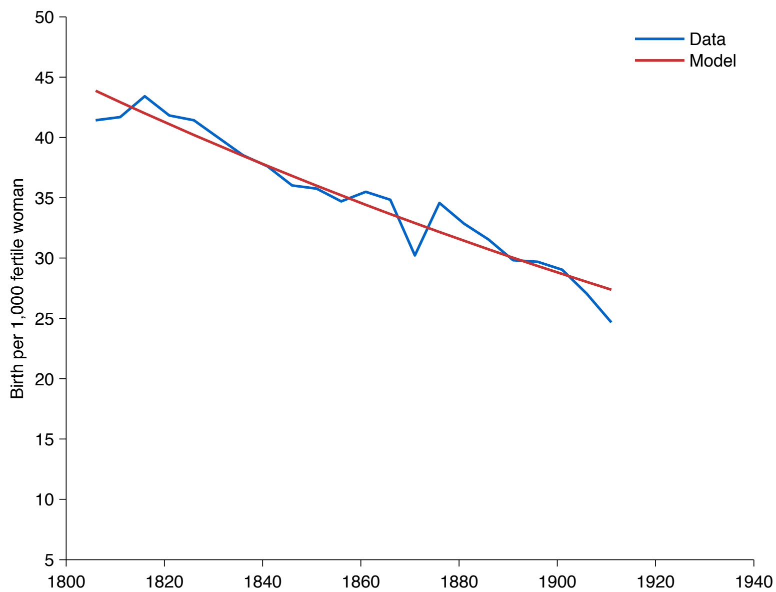
Source: Insee, état civil et recensement de population.

Figure 6: Proportion of Out-of-Wedlock Live Births in France



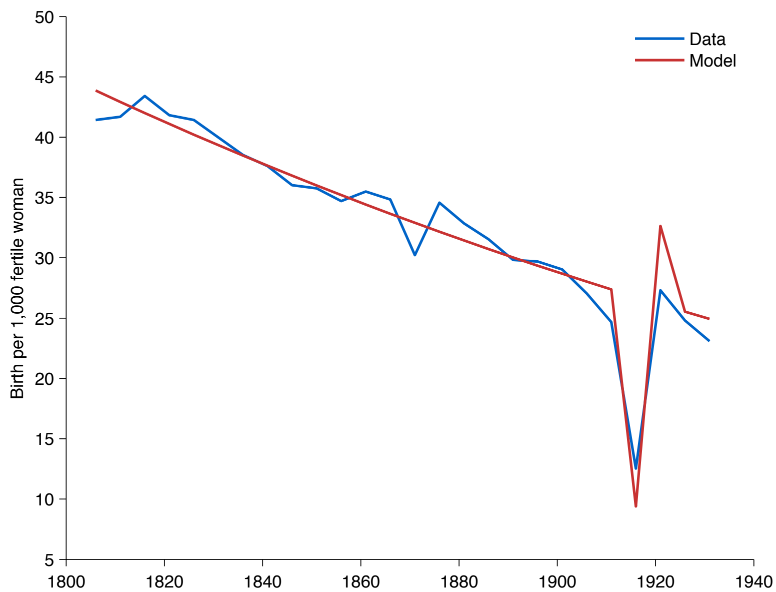
Source: Insee, état civil et recensement de population.

Figure 7: Fertility Rate in France, Model and Data, 1806–1911



Note: This figure displays the result of the calibration procedure where the model parameters are chosen to fit the time series of fertility during the pre-war period.

Figure 8: Fertility Rate in France, Baseline Experiment and Data, 1806–1931



Note: In the baseline experiment the generations affected by the war faces both an increased probability that their wives remain alone after the end of the war, and a temporary loss of their husbands' income during the war.

Figure 9: Fertility Rate Predicted by the Model by Age, Baseline Experiment, 1806–1931

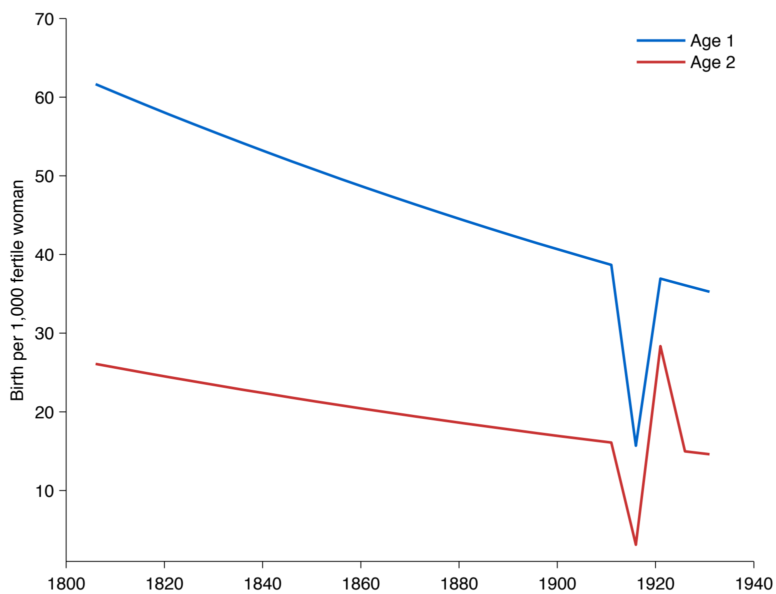


Figure 10: Fertility Rate Predicted by the Model, Baseline and Counterfactual Experiments, 1806–1931