Fertility and Wars: the case of world war I in France

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The Case of World War I in France[*]

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Abstract

During World War I (1914–1918) the birth rate in France fell by 50%. The corresponding deficit of births is estimated at 1.4 million, while military losses are estimated at 1.4 million too. Thus, the fertility decline doubled the demographic impact of the war. I construct a model of fertility choices where a household faces three shocks in a war: (i) an increased probability that its wife remains alone after the war; (ii) a partially-compensated loss of its husband's income; and (iii) a decline in labor productivity followed by faster growth. I calibrate the model's parameters to the time series of fertility before the war. I use military casualties and income data to calibrate the war. The model accounts for 91% of the observed decline, and overpredicts the subsequent rebound in fertility by 4%. The increased probability of a husband dying is the leading force behind the results.

1 Introduction

During the First World War (1914–1918) the birth rate in France declined by about 50%.[1] The resulting deficit of births, estimated to be 1.4 million, was as large as military losses estimated to be 1.4 million as well.[2] In short, the fertility decline doubled the already large demographic impact of the war, and its effect on the French demography was noticeable well into the twentieth century. I offer a quantitative theory to account for this phenomenon.

I develop a model that builds upon Greenwood et al. (2005). The unit of analysis is a finitely-lived household made of adults and children. The household derives utility from consumption as well as from the number of children it chooses to have. Children are costly, though. They require that the wife devotes a fraction of her productive time to them for as long as they remain in the household. In this model the war matters because the (likely) death of a husband is a pure, negative (expected) income shock. Since children are normal goods the war negatively affects fertility.

I propose a quantitative exercise consisting of two steps. First, I calibrate the model to fit the time series of the French fertility rate from 1800 until the eve of World War I. Second, I use the calibrated model to evaluate the effects of the war on fertility. I model the war as a change in the environment facing a household along three dimensions: (i) because of the war there is a non-zero probability that a wife remains alone raising the children; (ii) there is a partially-compensated loss of a husband's income because of the mobilization; (iii) there is a decline in productivity, followed by faster growth.

The calibrated model accounts for 91% of the observed fertility decline during the war. The key determinant of this result is the loss of expected income associated with the risk that a wife remains alone, that is (i). Other forces, that is (ii) and (iii), are quantitatively relevant taken one by one, but together they almost offset each others since a drop in earnings for a wife reduces the opportunity cost of raising children while for the husband it implies a negative income effect. The model also predicts an increase in fertility (4% more than in the data) after the war, fueled by a catch-up effect.

This paper contributes to a literature analyzing the consequences of the First World War on various aspect of the French population. Henry (1966) discusses the consequences of the war

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[1]See Figure 1.

[2]See Figure 2 for the size of the birth deficit. See Huber (1931, p. 413) for military losses. Military losses include people killed and missing in action. They do not include civilian losses.

for the marriage market and, more recently, Abramitzky et al. (2011) study the marriage market to evaluate the impact of the war on assortative matching. The closest studies are by Festy (1984) and Caldwell (2004). Festy (1984) offers a detailed description of the decline of fertility during the war. He concludes that *"the fertility decline during hostilities can be seen as a 'mechanical' consequence of the impossibility of procreating, rather than a deliberate attempt to avoid giving birth in such a troubled period."*[3] In short, Festy's theory is that feasible fertility declined while desired fertility remained constant. In this paper I propose a different approach: even without a reduction in feasible fertility, how far can a reduction in desired fertility go in accounting for the actual decline? Caldwell (2004) examines thirteen social crises, ranging from the English Civil War in the 17th century to the fall of communism. He documents noticeable falls in fertility in each case, and concludes that they were mostly temporary adjustments to the uncertainty of the time.[4] His results are consistent with the analysis that I carry out in this paper.

There are other economic theories of fertility beside the one on which I build my model. Many are reviewed in Jones et al. (2011). A well-known alternative is the so-called "quality-quantity" tradeoff theory proposed by Becker (1960). In these models, increases in wages induce parents to substitute the quantity of children for higher quality. It is worth noting that, if there is still a time cost of raising children paid by the wife only, then the effect of the war on fertility are, qualitatively, the same as in the model presented here. Thus, the analysis in this paper will carry over to alternative setups.

In the next Section I present statistics relative to the number of births and deaths during the war as well as to the composition of the Army. I also discuss relevant facts pertaining to the marriage market and the situation of women during the war. I develop my model and discuss the determinants of optimal fertility in Section 3. I present the quantitative analysis and the results in Section 4. I conclude in Section 5.

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

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[3]The quote from Festy is: *"La chute de la natalité pendant les hostilités peut donc être vue, par différence, comme une conséquence 'mécanique' de l'impossibilité de s'unir pour procréer, plutôt que comme une volonté délibérée d'éviter d'avoir des enfants dans une période aussi troublée."* (Festy, 1984, page 1003).

[4]See Table 1.

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 first month of World War I was August 1914, but the first 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.[5] 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 2, which shows the number of births per month in France and Germany. 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 1.4 million children not born. This figure amounts to 3.5% of the French population in 1914 (40 million) and is comparable to the military losses of the war: 1.4 million. The estimate for Germany is 3.2 million children not born. It amounts to 5% of the German population in 1911 (65 million) and exceeds the number of military deaths estimated at 2 million.[6] Similar calculations, made by demographers, lead to comparable figures: Vincent (1946, p. 431) reports a deficit of 1.6 million French births and Festy (1984, p. 979) reports 1.4 million.[7]

Figure 1 and Figure 2 show changes in contemporaneous fertility. They are silent about the long-term effects of the war. I discuss these effects now. I first show that the lifetime fertility of the generations affected by the war declined. Second, I show that the war changed the age-structure of the French population for the rest of the twentieth century.

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

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

[7]Another statistic of interest can be computed with the trend lines of Figure 2. The realized number of births between May 1915 and August 1919 was 52% of the expected number in France, and 57% in Germany.

1. Figure 3 shows completed fertility, a measure of realized lifetime fertility. Its main message is that the women who reached their twenties during the First World War gave birth, throughout their lives, to less children than the generations that preceded or followed them. Thus, even though there exist some evidence that women postponed their births until after the war was over (see Section 2.3), they did not fully compensate the forgone births of the war. If they had, their completed fertility would have remained unaffected by the war since one less child today would be made up for by one more child later on. Vincent (1946) argues that about half of the deficit of births during the war was compensated by the post-war rebound.

2. Figure 4 shows the age and sex structure of the French population at chosen dates. The differences between the pre- and post-war periods are noticeable. The 1930 panel shows a deficit of men (relative to women) in the 30-50 age group. These are the men that died during the war. There is also a deficit of both 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, fertility declined. 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.[8] Thus, births were low in the 1940s because the generation that was in its childbearing period at that moment, e.g. of age 25 in 1940, was born in and around World War I. This generation was unusually small, so it gave birth to unusually little children despite a high birth rate. Thus, the deficit of births during World War I lead, mechanically, to another deficit 25 years later because of a reduction in the size of the fertile population.

Figure 5 shows 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 World

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[8]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 that is consistent with this view.

War I. The United Kingdom appears to have experienced a reduced deficit of births during World War I compared with other European countries.

2.2 The Mobilization

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. Thus, almost all men served at some point during the war. In the model of Section 3 I use this observation to justify the assumption that all men serve in war.

The majority of soldiers were mobilized, that is they were called to serve and had to report to military centers of incorporation. Huber (1931, p. 94) reports that a small, albeit not negligible, number of men (229,000 men) volunteered into the army between 1914 and 1919. Those men chose to serve even though, at the time they did, they were not compelled to do so by law. On August 1st 1914, the day of the mobilization, the army counted already 1 million men. The remaining 7.5 million were incorporated throughout the four years of the war.[9] Throughout the war the army regularly reviewed cases of men exempted from military duty for whatever reason, and called large proportions of them to serve.

How feasible was it for mobilized men to conceive a child? It is difficult to answer this question with existing data. Being mobilized did not imply that a man was on the front line continuously. At any point in the war, 30 to 50% of mobilized men were 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.[10] In addition, leaves for the combat troop became more generous, albeit still short, from June 1915 onward.

I propose a simple accounting exercise to try and gauge the relative importance of the "feasible" fertility approach of Festy (1984) and the "desired" fertility approach of this paper. Let c denote the number of couples with a physical opportunity to conceive a child. Let b denote the desired number of births for a couple. The former is exogenous while the latter is a choice. The fertility rate is

$$f = \frac{\text{number of births}}{\text{number of fertile women}} = \frac{c \times b}{\text{number of fertile women}}.$$

[9] See Huber (1931, p. 89).
[10] See Huber (1931, p. 105).

I assume that the denominator is not affected by the war. I also assume, in line with the "feasible" fertility approach, that b is constant. Then, to account for the 50% decline in fertility during the war c needs to decline by 50%. After the war, however, c is less than before since 84% of the men that served survived. Thus, both the rate of fertility and the total number of births at the end of the war should be 84% of their pre-war level.[11] They were, in fact, higher –see Figure 1 and Figure 2. The lesson from this exercise is that changes in both the exogenous opportunity to conceive and fertility decisions are likely to have played a role. This paper evaluates the effect of the war on fertility choices only.

2.3   The Women

I present a set of facts related to the situation of women. There are (i) evidence suggesting that some women postponed births; (ii) evidence suggesting that the marriage market was disrupted but that out-of-wedlock births increased; (iii) evidence suggesting that women's labor force participation did not change dramatically.

1. Figure 6 shows that the age of women giving birth increased during and after the war. This observation suggests that young women postpone giving birth during the war and caught-up later, while slightly older themselves. In the model of Section 3 a household has the option to exploit a similar margin to smooth the cost of the war.

2. Henry (1966) shows that the marriage market was noticeably perturbed for the generations reaching their marriage and childbearing years during the war. Many marriages were postponed. After 1918, women married men of their age or younger more than they usually did, because the men they would have normally married were dead. Interestingly, however, the spinster rate at age 50 for women that should have married during the war differs little than that of other generations.[12] Note, however, that from the perspective of a woman during the war, marriages prospects in the aftermath of the war may have appeared quite uncertain. Finally, note that the disruption in the marriage market does not imply that births are affected. Although it is common, it is not necessary to be married to have children. Figure 7 shows that the proportion of

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[11]I assume here, as in the model of Section 3, that all men were in a couple when the war broke out, and that if they do not survive the "couple" becomes sterile.

[12]Henry (1966) reports that the proportion of single women, at the age of 50, for the 1891-1895 generation is 12.5%, and that 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%.

out-of-wedlock births increased significantly during the war. In the model of Section 3 I abstract from the marriage market. In light of the evidence just presented, this seems a reasonable abstraction.

3. Little information is available on female labor during the war. 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 that 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 was moderated by the fact that between 80 and 95% of the women who worked during the war were already working before: "*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.*" (Downs, 1995, page 48) In the model of Section 3 a woman's labor is exogenous which, in light of the evidence just presented, seems a reasonable abstraction.

3   The Model

I start by describing the benchmark model in Section 3.1. The benchmark model describes an economy at peace, but most of the intuition needed to understand the effect of an unexpected war can be grasped from it. In Section 3.2 I introduce the war explicitly into the model, to lay out the framework for the quantitative analysis of Section 4.

3.1   The Benchmark Model

The economy is populated by overlapping generations of individuals whose lives are made of two stages: childhood and adulthood. Children are born into households headed by two

adults and, each period, a fraction $1 - \nu$ of them leave.[13] The assumption that children remain in the household for some time after their birth is relevant for the quantitative exercise of Section 4 since, all else equal, children are costlier when they stay longer.

After leaving the household children become age-1 adults and pair with other age-1 adults to form new households. The household formation process is exogenous. Households live for J periods and are the only decision makers.

The Preferences

A household's preferences are defined over streams of consumption and the number of children present. They are represented, for generation τ, by the utility function

$$\sum_{j=1}^{J} \beta^{j-1} \left[U \left(\frac{c_{j,\tau}}{\phi(n_{j,\tau} + b_{j,\tau}, 2)} \right) + \theta V(n_{j,\tau} + b_{j,\tau}) \right],$$

where the parameter $\beta \in (0,1)$ is the subjective discount factor. Total household consumption at age j is denoted $c_{j,\tau}$. The number of children present at age j comprises children already born and still in the household, denoted by $n_{j,\tau}$, and newborn of the period, denoted by $b_{j,\tau}$. The function $\phi(\cdot, 2)$ is an adult-equivalent scale where 2 denotes the number of adults. The parameter θ is positive and U and V are concave, twice-continuously differentiable utility indexes. I assume

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

with $\sigma, \rho > 0$.

I assume that a household values consumption per (adult equivalent) member, instead of total consumption, to account for a mitigating effect of the war on the cost of children. Namely, when a husband dies, all else equal, consumption per member increases and its marginal utility decreases. Hence, allocating resources toward raising children becomes cheaper. Note the assumption that children are perfect substitute regardless of their age. This is for simplicity.

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[13]After J periods all remaining children leave.

The Timing of Fertility

A household chooses how many children to give birth to at age 1 and 2, that is $b_{1,\tau}$ and $b_{2,\tau}$. From age 2 onward it is "sterile," that is $b_{j,\tau} = 0$ for $j > 2$. I model the timing of births because it may be quantitatively important in light of the evidence, presented in Section 2.3, that some women postponed giving births until after the war was over. Not modeling this margin would exaggerate the cost of the war for a household who could give birth only during the war. In Section 4 I assume that the war lasts for one model-period, and even though its duration is uncertain from the perspective of a household, there is the option to delay fertility and have children later.

The Allocation of Time and Income

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 γ units of a wife's time for each period during which it is present in the household. The parameter γ represents technology. It is not a control variable. Instead, a wife's time allocation is indirectly controlled through the number of children she gives birth to.

Wage rates are gender specific. Let w_t^i, $i = m, f$ denote the wage rate for husbands and wives, respectively. I assume that both wages grow at the constant (gross) rate $g > 1$ each period: $w_{t+1}^i = g w_t^i$. Given these specifications, the labor income of an age-j household of generation τ with $n_{j,\tau}$ children already born and present, and $b_{j,\tau}$ newborn is

$$w_{\tau+j-1}^m + w_{\tau+j-1}^f - \gamma w_{\tau+j-1}^f (n_{j,\tau} + b_{j,\tau}).$$

Beside labor income, I also assume that 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.

The Optimization

It is convenient to describe the optimization problem of a household recursively. Let $W_{j,\tau}(a, n)$ denote the value of an age-j household of generation τ with assets a and n

children already born. Then,

$$W_{j,\tau}(a,n) = \max_{c,a',b} U\left(\frac{c}{\phi(n+b,2)}\right) + \theta V(n+b) + \beta W_{j+1,\tau}(a',n') \tag{1}$$

subject to

$$c + a' + \gamma w^f_{\tau+j-1}(n_{j,\tau} + b_{j,\tau}) = w^m_{\tau+j-1} + w^f_{\tau+j-1} + \frac{a}{\beta} \tag{2}$$

$$n' = \nu(n+b) \tag{3}$$

Equation (2) is the budget constraint. Equation (3) describes the number of children that remain in the household next period: a fraction ν of them. The following additional restrictions are also imposed: $b = 0$ for $j > 2$ since the household is fecund only at age 1 and 2; a and n are both zero at age 1 since the household is born without assets nor children; $a' = 0$ when $j = J$ since the household cannot save/borrow during the last period of its life.

The first order conditions for consumption and savings imply the Euler condition

$$U_1\left(\frac{c}{\phi(n+b,2)}\right)\frac{1}{\phi(n+b,2)} = U_1\left(\frac{c'}{\phi(n'+b',2)}\right)\frac{1}{\phi(n'+b',2)}, \tag{4}$$

while the first order conditions for consumption and fertility (at age $j = 1,2$) can be rearranged into

$$\theta V_1(n+b) + \beta\nu W_{j+1,\tau,2}(a',n') =$$
$$U_1\left(\frac{c}{\phi(n+b,2)}\right)\frac{1}{\phi(n+b,2)}\left(\gamma w^f_{\tau+j-1} + \frac{c}{\phi(n+b,2)}\phi_1(n+b,2)\right). \tag{5}$$

For the sake of exposition consider the special case where $\nu = 0$, and $\phi(n+b,2) = 1$. Then Equation (5) reads

$$\theta V_1(n+b) = U_1(c)\gamma w^f_{\tau+j-1}, \tag{6}$$

stipulating that at an optimum the marginal rate of substitution between children and consumption equals the relative price of children. Most of the qualitative properties of fertility in the model can be grasped from an inspection of Equation (6). This is because by assuming $\nu = 0$ and $\phi(n+b,2) = 1$, I abstract from two features of the model designed to quantitatively assess the war, but having no bearings on the qualitative properties of the model. These features are the assumption that children remain in the household for some periods after they are born; and the assumption that the household values consumption per

member.

Equation (6) shows how the model is able to replicate the secular decline in fertility before the war. As wages and consumption increase, fertility increases or decreases depending upon the relative magnitudes of the income and substitution effects. Note that changes in a husband's wage imply only an income effect while for the wife there are both income and substitution effects. For fertility to decrease, the substitution effect must dominate.

Equation (6) also helps to understand two effects of a war: the contemporaneous drop in fertility and the post-war catch-up. To see this, I assimilate a war to a negative income shock that lowers consumption and, therefore, raises the marginal cost of children. This implies a drop in fertility as illustrated in Figure 8. Such low fertility implies that, in the period following a war, a still-fertile household has a low stock n of children. Thus, the marginal utility of children is high and fertility increases. This is illustrated in Figure 9.

There are differences between Equation (5) and Equation (6), though. This is because children remain in the household beyond the period of their birth, yielding utility and being costly at the same time. The net, present value of these effects is measured in Equation (5) by the term $\beta\nu W_{j+1,\tau,2}(a', n')$. Another difference between Equations (5) and (6) pertains to the right-hand side. Since a household values consumption per member it is the marginal utility of consumption per member that measures the cost of resources, hence the term $U_1(c/\phi(n + b, 2))/\phi(n + b, 2)$. In addition a newborn requires a share of consumption, hence the term $c/\phi(n + b, 2) \times \phi_1(n + b, 2)$.

To sum up, the effects discussed above are at the core of the model's ability to generate a downward trend in fertility punctuated by a negative response of fertility to the war, and a rebound in the period following the war.

3.2   The War and its Aftermath

In this section I introduce, formally, the notion of a war in the model. This is important for the quantitative exercise of Section 4. As will transpire later, the size of the income effect associated with the war is determined, to a large extent, by the likelihood of a husband dying in war. This section introduces the apparatus for this discussion.

I start by defining $\omega_t \in \{\text{peace,war}\}$ to denote the state of the world. I also define $z_{j,\tau} \in \{1, 2\}$ as the number of adults in an age-j household. Both ω_t and $z_{j,\tau}$ are random variables.

Their realizations are observed at the beginning a period, before any decisions are made.

I make the following assumptions about the distribution of ω_t and $z_{j,\tau}$. In peace, a war is not anticipated. In war, the probability of peace next period is denoted by q. In peace, the number of adults in a household is constant. In war the probability of a husband dying is denoted by p. I abstract from the possibility of remarriage, i.e. $z_{j,\tau} = 1$ is an absorbing state. Finally, I maintain the assumption that $z_{1,\tau} = 2$, that is a newly-formed household comprises two adults.

A household's optimization problem writes now

$$W_{j,\tau}(a, n; z, \omega) = \max_{c, a', b} U\left(\frac{c}{\phi(n + b, z)}\right) + \theta V(n + b) + \beta E\left[W_{j+1,\tau}(a', n'; z', \omega')\right], \quad (7)$$

subject to

$$c + a' + \gamma w^f_{\tau+j-1}(\omega)(n_{j,\tau} + b_{j,\tau}) = \begin{cases} w^m_{\tau+j-1}(\omega) + w^f_{\tau+j-1}(\omega) + a/\beta & z = 2 \\ w^f_{\tau+j-1}(\omega) + a/\beta & z = 1 \end{cases} \quad (8)$$

where E is the expectation operator. The problem is subject to the additional restriction that a 1-adult household cannot have children. Note that if there is a war in the current period and the husband survives it, the probability that he does not survives the next period is $(1 - q)p$.

I complete the problem with a description of the relationship between wages and the state of the world: $w^i_t(\omega)$. I assume, that wages drop by a proportion π^i during the war, remain constant as long as the war continues, and grow at the constant rate $g_{\text{post war}} > g$ when peace returns. Formally

$$w^i_{t+1}(\text{peace}) = w^i_t(\text{peace}) \times \begin{cases} g & \text{before the war} \\ g_{\text{post war}} & \text{after the war} \end{cases} \quad (9)$$

in peace, and

$$w^i_t(\text{war}) = \left(1 - \pi^i\right) \times w^i_{\text{last period before war}} \quad (10)$$

$$w^i_{t+1}(\text{peace}) = g_{\text{post war}} \times w^i_t(\text{war}) \quad (11)$$

in war. Note that, in peace, the probability of a war is zero. So there is no definition for $w^i_t(\text{war})$ in peace time.

This optimization problem subsumes the benchmark model as a special case. Namely, if a war never occurs the choices of any generation of households are the same as they would be in the benchmark model. This derives immediately from the assumption that households do not anticipate a war and that the number of adults in a household remains constant in peace time.

The first order conditions are similar to that of the benchmark model. For fertility, this is true only for households with two adults since I assume that a 1-adult household cannot have children. The first order condition for $b_{j,\tau}$ becomes

$$\theta V_1(n+b) + \beta\nu E[W_{j+1,\tau,2}(a', n'; m'\omega')] =$$
$$U_1\left(\frac{c}{\phi(n+b,2)}\right)\frac{1}{\phi(n+b,2)}\left(\gamma w_{\tau+j-1}^f(\omega) + \frac{c}{\phi(n+b,2)}\phi_1(n+b,2)\right) \quad (12)$$

for $j = 1, 2$. The interpretation of Equation (12) is similar to that of Equation (5).

I describe now the effects of p, q, π^i and $g_{\text{post war}}$. An increase in p, the probability of a husband dying in war amounts to a negative expected income shock. The household reduces its consumption, and, as discussed in Section 3.1, this leads to a decrease in fertility. A decrease in q, the probability of peace next period, acts in a similar way since it makes it more likely that the husband will die, if not in this period in the next. Note, however that a decrease in q also makes it less likely for the household to be able to postpone giving birth until peace returns. Thus q has ambiguous effects on fertility. The parameter π^m yields a contemporaneous, negative income effect. The parameter π^f yields contemporaneous income and substitution effects. The effect of faster growth after the war, $g_{\text{post war}}$, depends also on income and substitution effects. Consider the (empirically relevant) case where the substitution effect dominates. Then households are induced to have children earlier. This dampens the fertility decline during the war.

4 Quantitative Analysis

4.1 Calibration of the Benchmark Model

In this section I calibrate the model to pre-World War I data for France. I treat this period as being without wars. Several of the model's parameters are chosen a priori. Others are chosen to minimize the distance between actual and predicted fertility.

A period in the model corresponds to 5 years in the data. Thus, an age-1 individual in the model corresponds to a child between the age of 0 and 5 in the data. I choose ν so that the expected duration of childhood is 4 periods.[14] This choice implies $\nu = 0.80$. Households live for $J = 7$ periods.

I let the rate of interest on the risk free asset be 4% per year. This implies a subjective discount factor $\beta = 1.04^{-5}$. I use the rate of growth of the Gross National Product per capita in the 19th century, 1.6% per year, for the growth rate of wages.[15] This implies $g = 1.016^5$. 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 of 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.

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:

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

I now turn to the remaining parameters, $\alpha \equiv (\sigma, \theta, \rho, \gamma)$. I construct a time series of the French fertility rate using the birth rate and the proportion of women between the age of 15 and 44 from Mitchell (1998). Let $\mathbf{f}_t$ denote this data. I compute model fertility as an equally-weighted average of the fertility of age-1 and age-2 women at date t:

$$f_t(\alpha) = \frac{b_{1,t}(\alpha) + b_{2,t-1}(\alpha)}{2}.$$

I adopt this specification for simplicity. Actual fertility is, in fact, weighted by the relative size of each generation. French data show these weights to be remarkably stable about 50% in the 19th century.[16] In the model, however, declining fertility implies counterfactual predictions for the growth rate and age-composition of the population, unless exogenous

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[14]The probability that a children remains in the household for one more period is ν until age 6. At age 7 this probability is 0. Hence the expected duration of childhood is $\sum_{j=1}^{6} j\nu^{j-1}(1-\nu) + 7\nu^6$.

[15]see Carré et al. (1976, Tables 1.1 and 2.3).

[16]Mitchell (1998, Table A2) reports data showing that the ratio of women aged 25-29 to women aged 20-29, for example, is remarkably stable, about 50%, between 1851 and 1911. The same results hold for the 30-34 group relative to the 25-34 and other groups.

trends in life expectancy and possibly migration are taken into account.[17] Such additions would be orthogonal to the issue being studied. Thus, using the observed weights of 50% appears to be a reasonable simplification that is also consistent with the data. Formally, I solve the following minimization problem:

$$\min_{\alpha} \sum_{t \in \mathcal{I}} [f_t(\alpha) - \mathbf{f}_t]^2 + [\gamma(b_{1,1906}(\alpha) + b_{2,1906}(\alpha)) - 0.1]^2 \tag{13}$$

where $\mathcal{I}$ is an index set: $\mathcal{I} = \{1806, 1811, 1816, \ldots, 1906\}$. The second part of the objective function is the distance between the time spent by the 1906 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 and childcare (61 hours). Thus, γ is set to imply that the time spent by a women on childcare, on the eve of the war, is 10% as well. In Section 4.4 I present sensitivity results with respect to the target figure for the time cost of raising children.

I motivate this calibration as follows. The model predicts a decline in fertility only if the income effect of wages is dominated by the substitution effect (see Section 3). Thus, the downward trend in the times series of fertility restricts the size of the income effect on fertility. The logic of the experiment that I propose is to use this discipline to assess the effect of a particular income shock: the war.

The calibrated parameters are displayed in Table 2. Figure 11 displays the computed and actual fertility rate for the pre-war period. Note that, by construction, the parameters of the model imply an elasticity of fertility to income of $\ln(100/160)/\ln\left(1.016^{100}\right) = -0.28$, since fertility declines from about 160 to 100 in the century before the war. This figure is within

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[17]Let $p_{j,\tau}$ denote the age-j adult population of generation τ. Assuming that children become adults in one period implies that the age-1 adults of generation $\tau + 1$ are born from age-1 and age-2 adults in the previous period. That is from generation τ and $\tau - 1$. Thus, $p_{1,\tau+1} = p_{1,\tau}b_{1,\tau} + p_{2,\tau-1}b_{2,\tau-1}$. Dividing by $p_{1,\tau}$ yields

$$\frac{p_{1,\tau+1}}{p_{1,\tau}} = b_{1,\tau} + \frac{p_{2,\tau-1}}{p_{1,\tau}}b_{2,\tau-1}.$$

Note the terms $p_{1,\tau+1}/p_{1,\tau}$ and $p_{2,\tau-1}/p_{1,\tau}$. The first is the growth rate of population, namely the growth rate of the age-1 adult cohort. The second is the old-to-young adult ratio at date τ. In the french data both terms are constant in the 19th century, while $b_{1,\tau}$ and $b_{2,\tau-1}$, decrease. The equation above is then inconsistent with this observation. In other words, the model cannot fit at the same time the decline in fertility, the constant growth rate of population, and its age composition, without additional determinants of population dynamics.

the range of estimates centered around minus one-third reported by Jones et al. (2011, Table 1) for cross-sectional data in the United States. Unfortunately, although there exist detailed fertility statistics by regions for France during the 19th century, no cross-sectional income statistics are available.

4.2 Baseline Experiment

Parameters Representing the War

I assume that the war breaks out in 1916 and lasts for one single period. That is, the *realized* values of ω are $\omega_t = $ peace for all $t \neq 1916$, and $\omega_{1916} = $ war. I consider three values for the probability that the war ends after one period: $q \in \{1.0, 0.9, 0.8\}$.

I calibrate p, the probability that a wife is alone after one period of war as

$$p = \frac{\text{military losses of World War I}}{\text{total men mobilized}}.$$

There were 1.4 million military losses and 8.5 million men were mobilized. This implies $p = 1.4/8.5 = 0.16$. This figure is not perfect. On the one hand it may exaggerate the risk for a wife since remarrying was possible. On the other hand it may underestimate the risk since not all mobilized men were exposed to combats. Also, a husband may survive the war but come home disabled.[18] In Section 4.4 I present sensitivity results with respect to p to address these concerns.

I now turn to the calibration of π^m, π^f and and $g_{\text{post war}}$. Figure 10 shows a 30% decline of output per worker in France between 1913 and 1919, followed by an annual rate of growth of 2.5% from 1919 to 1930. Thus, I use $\pi^f = 0.3$ to represent the drop in productivity of a wife, and $g_{\text{post war}} = 1.025^5$. When a man is mobilized he does not work, so the husband's wage is interpreted as a transfer to the household with a mobilized husband – a compensation. Downs (1995) reports compensations amounting to somewhere between 35 and 60% of a man's pre-war salary in agriculture or industry.[19] I use $\pi^m = 0.5$.

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[18]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.

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

Discussion of Results

The main results of this experiment are three-fold. Fertility decreases noticeably during the war because all fertile households choose to have less children. Once the war is over, that is in 1921 in the model, there is a rebound in fertility because the households that are still fertile catch-up. Finally, lifetime fertility is reduced for the generations exposed to the war during their fertile years.

I now describe these results in more details for the case of $q = 1$, that is when households expect the war to last only one period. Figure 12 shows the time path of fertility. Table 3 summarizes the results. In 1916, the fertility rate predicted by the model falls by 45% relative to 1911, versus a 49% fall in the data. Thus, the model accounts for 91% of the data ($45/49 = 0.91$).

In 1921 fertility is 123% above its 1916 value in the model. The corresponding figure in the data is 118%. Thus, the model over predicts by 4% the post-war increase. To interpret this result Figure 13 plots fertility by age, conditional on a husband being in the household. Households without husbands have zero fertility. Consider first the 1911 cohort. In 1911 it is age 1 and does not anticipate the war. So its age-1 fertility is on trend. In 1916 it is age 2. There is a stock of already-born children but the war is on. It is then forced to reduce its fertility to bear the cost of the already existing children.

Consider now the 1916 cohort. It reduces its age-1 fertility in 1916 because its current and expected income is low. In 1921, if the husband survives, its fertility does not return to trend, though. It is above trend because the stock of children in the household is "abnormally" low and therefore the marginal utility of children is high. Hence fertility is high as well. Note that this effect is mitigated in overall fertility since a fraction p of husbands in this generation died. Indeed, overall fertility for 1921 is computed as

$$\frac{b_{1,1921} + (1-p)b_{2,1916}}{2}.$$

It transpires from the results that the effect of p is dominated by the increase in $b_{2,1916}$.

Figure 14 shows lifetime fertility by cohort. That is, for cohort τ, the figure plots $b_{1,\tau} + b_{2,\tau}$ (multiplied by 5 since a model-period is 5 years). Two points are worth mentioning. The 1911 cohort reduces its lifetime fertility the most. This is because, even though it has trend fertility at age 1, it is forced to reduce its fertility noticeably at age 2. The 1916

cohort reduces its lifetime fertility, but less. This is because the decrease during the war is compensated by the increase in 1921.

I now make a few additional observations about the results. First, Table 3 shows cases where households expect that the war continues with some probability, that is $q < 1$. The results are relatively close to those discussed here. This is because there are two offsetting effects of a decrease in q. On the one hand, a decrease in q magnifies the risk associated with the war and, therefore, exacerbates the fertility adjustment. On the other hand, when a young household expects the war to be over in the next period it has an incentive to reallocate births into the future. This incentive is weakened by increases in the probability that, in the future, the war can still be on. Second, post war fertility is briefly above trend because productivity is still below trend immediately after the war. Post war fertility, however, declines fast because of the faster growth rate in productivity. Third, Figure 13 shows that age-1 households have above-trend fertility after the war, while age-2 households have below trend fertility. This results from faster growth again: future children appear relatively costlier to post-war generations than to pre-war generations. Hence the shift of births toward younger age.

4.3   Decomposition

To evaluate the contributions of the various components of the war I conduct a set of 4 experiments. Remember that the war is represented by four parameters: $\Delta = (p, \pi^m, \pi^f, g_{\text{post war}})$ in addition to q, the probability that peace returns next period. In the first experiment I consider $\Delta = (p, 0, 0, g)$ so that the only effect of the war is that husbands may die. There are no effects on productivity. In the second experiment $\Delta = (0, \pi^m, 0, g)$ so that the only effect of the war is to reduce the husband's wage. In the third experiment $\Delta = (0, 0, \pi^f, g)$ so that the only effect of the war is to reduce the wife's wage. In the third $\Delta = (0, 0, 0, g_{\text{post war}})$ so that the war only accelerates growth.

Table 3 and Figure 15 show the results of these experiments. The key finding, here, is that the shock to expectations (Experiment 1) is necessary to understand, quantitatively, the effect of the war on fertility. As the table shows, when the war implies only a shock to expectations, the decline in fertility accounts for 100% of the decline in the baseline experiment. The increase after the war accounts for 79% of the increase in the baseline experiment. This result does not imply that other shocks are quantitatively irrelevant in their own rights. What transpires from experiment 2, 3 and 4, however, is that the various

shocks to productivity tend to offset each others.

The effects of π^m and π^f on fertility are relatively simple to interpret. The shock to π^m (Experiment 2) is a temporary, negative income shock. Quantitatively, it accounts for 42% of the decline in fertility in the baseline experiment. The shock to π^f (Experiment 3) implies both income and substitution effects with the latter dominating, as is implied by the calibration strategy adopted in Section 4.1. Thus, its effect is to increase fertility by 12% during the war.

The growth rate $g_{\text{post war}}$ (Experiment 4), on its own, tends to raise fertility during the war and to reduce it in 1921. This is because an increase in the growth rate raises the cost of having children late in life. Thus, in 1916 when steeper wage profiles are expected, age-1 households increase their current fertility at the expense of their age-2 fertility. In an experiment were $g_{\text{post war}} = g$ but all the other shocks are as in the baseline experiment, that is $\Delta = (p, \pi^m, \pi^f, g)$, I find that that the model account for 94% of the decline during the war and over predicts the post-war increase by 5%. In this experiment, unlike in the baseline, the post-war fertility of both age-1 and age-2 households are above their pre-war trends. In sum, even though the growth rate of wages matter for the timing of fertility, its effect on overall fertility are quantitatively smaller than that of other variables.

Noe, to conclude, that despite the fact that the shock to expectations is the main driver of the results, changes to expected household income is not enough to predict the effect of the war on fertility. In the baseline experiment, the expected income of an age-1 household in 1916 is 45% less than it would have been if the war had not broken out. In experiment 1, which yields a similar response of fertility, the household's expected income only drops by about 8%. The reason for this is that changes to the household's expected income in the baseline experiment masks mutually offsetting effects that are absent in Experiment 1.

4.4   Sensitivity

I consider alternative values for (i) the probability that a woman remains alone after the war, p; (ii) the magnitude of the husband's income loss during the war, π^m; (iii) the time cost of raising children, γ; and (iv) the gender wage gap in earnings, w^f/w^m. Table 4 reports the results of this analysis for the case where $q = 0$. The main lesson to take away from this exercise is that even with noticeable changes in parameters' value, the model generates sizeable changes in fertility during and after the war.

Setting the probability that a woman is alone after the war to 10% instead of the baseline value of 16% yields a 33% decline in fertility. This accounts for 67% of the actual decline instead of 91% in the baseline. An interpretation of this experiment is that it is an indirect way of accounting for the remarriage option that war widows had but that the model abstracts from. When $p = 20\%$, the decline in fertility is more pronounced than in the baseline: 49%. Turning to π^m: when $\pi^m = 0.75$ instead of the baseline value of 50%, a household receives only a quarter of it's husband pre-war income as a compensation during the war. This exacerbates the effect of the war: fertility decline by 53%, over predicting the actual decline by 8%. When $\pi^m = 0.25$, the decline in fertility is 42%. It is interesting to note that the results are more sensitive to changes in p than π^m: a change in p by a factor of 2 yields a 50% increase in the fertility decline predicted by the model. Changing π^m by a factor of 3 yields a 26% difference in the results. This is a reassuring result since π^m is a parameter that is difficult to gauge, the only source I used being Downs (1995).

Finally, I note that in the experiments where the gender wage gap and the time cost of a child differ from the baseline, the model is recalibrated to the time series of fertility. 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 15% instead of 10%. 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 children implies 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 fertility 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. Thus, on the one hand households have an incentive to reduce fertility more than in the baseline during a war because children are costlier, but on the other hand, since the marginal utility of a child is higher reducing fertility is also costlier than in the baseline. These two opposing effects almost offset each others when the time cost of raising a child is 15%.

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. This affected the age composition of the French population for the rest of the twentieth century. I presented a

quantitative theory of this phenomenon. In the model children yield utils, but they require time to be raised. The war is tantamount to an income shock, both contemporaneous and expected. I calibrated the model to the time series of pre-war fertility. I found that the war triggered a large negative response of fertility, accounting for 91% of the observed decline. The model also features a mechanism to account for the post-war rebound in fertility. Its calibrated version overpredicts this rebound by 4%.

The key determinant of these results is the loss of expected income associated with the risk that a wife remains alone after the war. Even though the war also features shocks to wages for both husband and wives, these other forces offset each others.

Although the analysis that I presented is about France during the First World War, neither France nor World War I are unique cases. As is clear from Figure 1 other belligerents of the war experienced the same fate as France. Furthermore, there is evidence, presented by Caldwell (2004), that fertility declined in many countries during various episodes of wars, civil wars, revolutions and dictatorships –see Table 1. The conclusions that I reach in this analysis could be extended to these episodes in future research.

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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 stands for Crude Birth Rate. Caldwell 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.

Table 2: Calibration

|	
Preferences	$\beta = 1.04^{-5}$, $\theta = 0.216$, $\rho = 0.644$, $\sigma = 0.815$
Wages	$w^m = 1, w^f = 0.6$ for initial (1806) generation
	$g = 1.016^5$
Cost of children	$\gamma = 1.01$
Adult equivalent scale	$\phi(n, m) = 1/2 + m/2 + 0.3n$
Demography	$J = 7$, $\nu = 0.805$

Table 3: Changes in Fertility, %

	$q = 1$		$q = 0.9$		$q = 0.8$	
	1911-16	1916-21	1911-16	1916-21	1911-16	1916-21
Data	−49	+118	−49	+118	−49	+118
Baseline Experiment	−45	+123	−45	+126	−46	+129
Baseline/data	0.91	1.04	0.92	1.07	0.93	1.09
Counterfactual Experiments:						
1 – war with only p	−45	+97	−45	+99	−45	+100
Exp. 1/Baseline	1.00	0.79	1.00	0.79	0.99	0.78
2 – war with only π^m	−19	+28	−19	+27	−19	+27
Exp. 2/Baseline	0.42	0.23	0.41	0.22	0.41	0.21
3 – war with only π^f	+12	−5	+13	−5	+13	−5
Exp. 3/Baseline	−0.28	−0.04	−0.28	−0.04	−0.28	−0.04
4 – war with only $g_{\text{post war}}$	+4	−10	+3	−9	+3	−8
Exp. 4/Baseline	−0.08	−0.09	−0.07	−0.07	−0.06	−0.06

Table 4: Sensitivity Analysis: Changes in Fertility During and After the War when $q_{1916}(\text{war}) = 0$, Model and French Data, %

	1911-16	1916-21
Data	-49	$+118$
Baseline	-45	$+123$
$p = 0.10$	-33	$+80$
$p = 0.20$	-49	$+144$
$\pi^m = 0.25$	-42	$+110$
$\pi^m = 0.75$	-53	$+165$
Time cost of children 5%	-20	$+31$
Time cost of children 15%	-40	$+95$
$w^f/w^m = 0.65$	-38	$+84$
$w^f/w^m = 0.55$	-43	$+99$

Figure 1: Birth Rates in Some European Countries
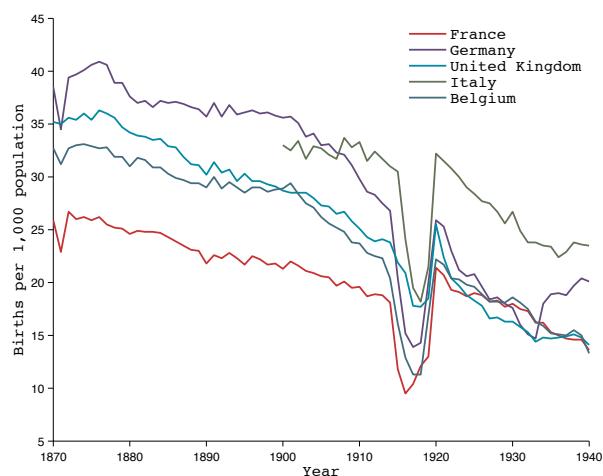
Source: Mitchell (1998).

Figure 2: Number of Births per Month in France and Germany
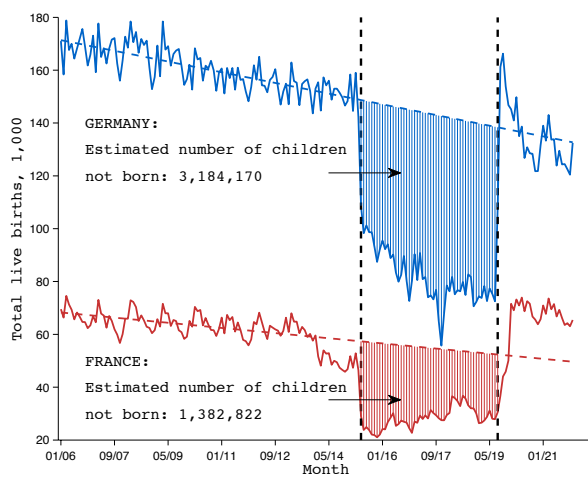
Note: The source of data is Bunle (1954, Table XI). The linear trends are estimated using the data from January 1906 until July 1914. The area between the two vertical lines runs from May 1915, that is 9 months after the declaration of war between France and Germany in August 1914, until August 1919 that is 9 months after the armistice was signed in November 1918.

Figure 3: Completed Fertility in France
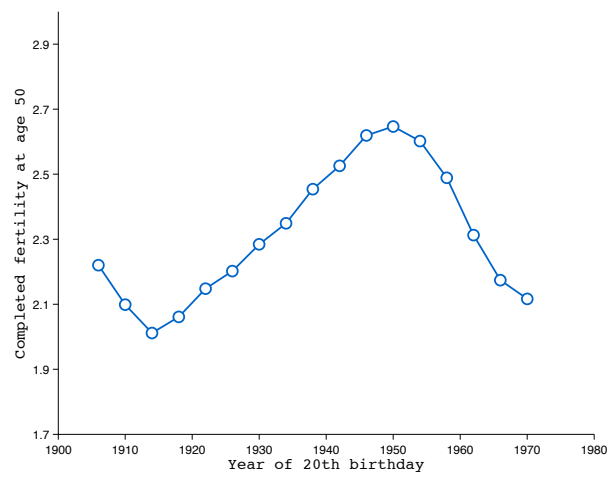
Source: Insee, état civil et recensement de population.
Completed fertility is the average number of children born to a woman of a particular cohort, once she has reached age 50.

Figure 4: French Population by Age and Sex, January 1, Selected Years

1910

1930

1950

1970
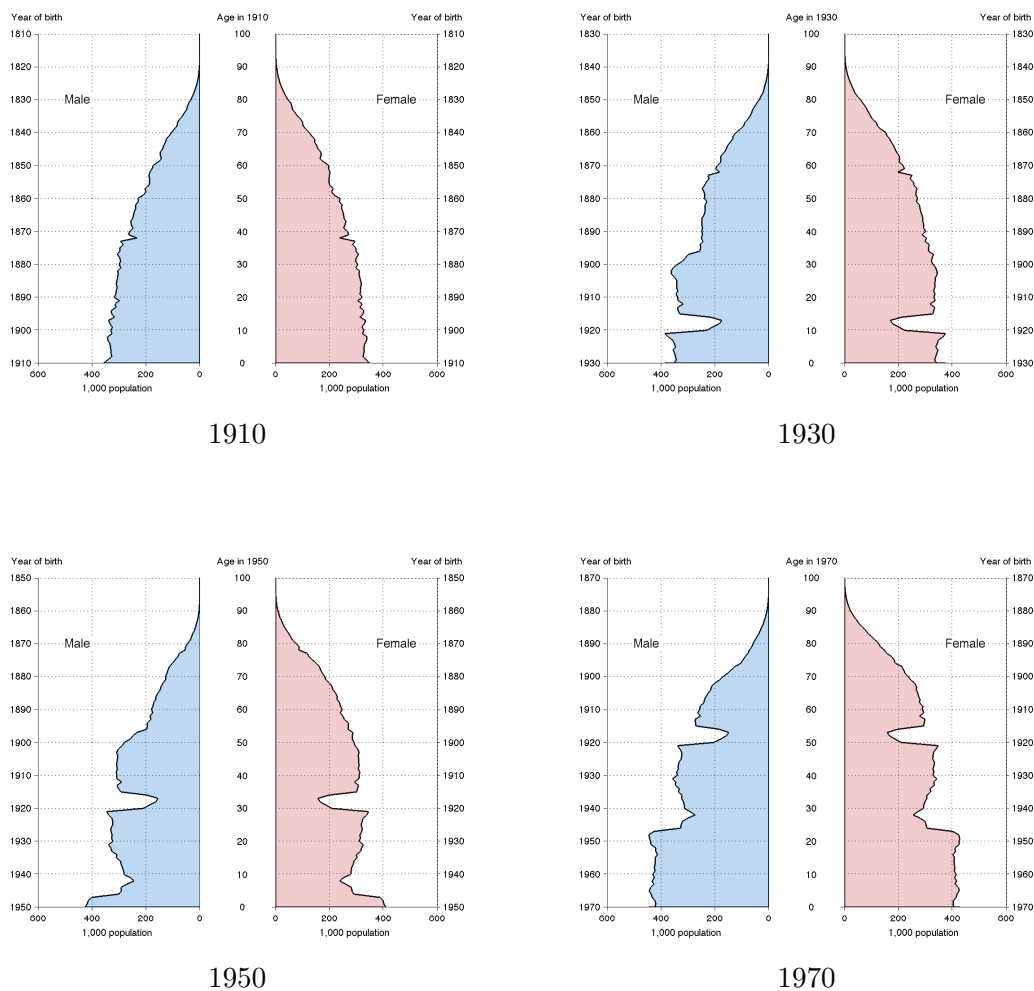
Source: Insee, état civil et recensement de population.

Figure 5: Population by Age and Sex, Selected Countries, 1950

Germany

Belgium

United Kingdom

Italy

Europe

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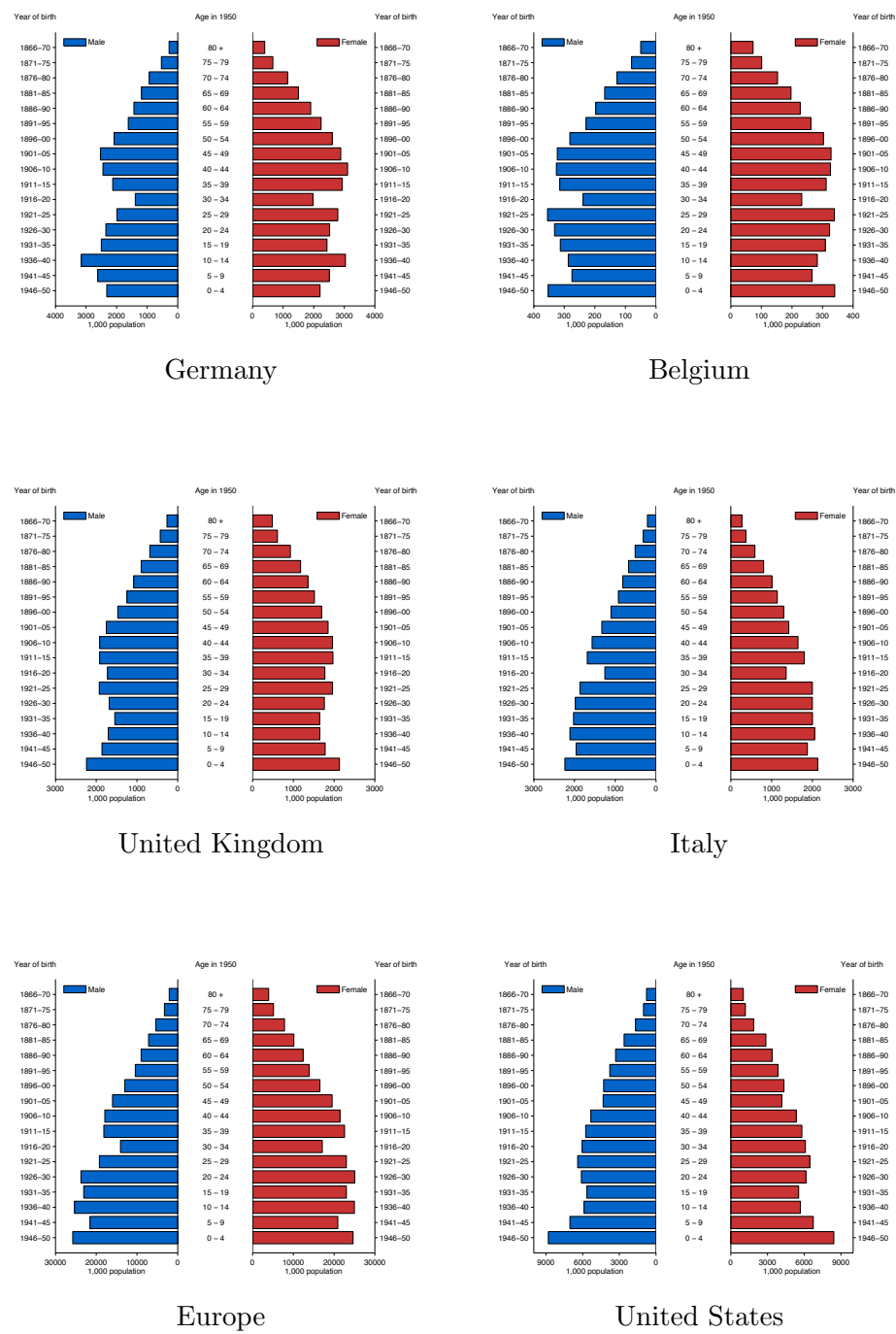
Source: United Nations, Department of Economic and Social Affairs, Population Division.

Figure 6: Average and Median Age of Women Giving Birth in France
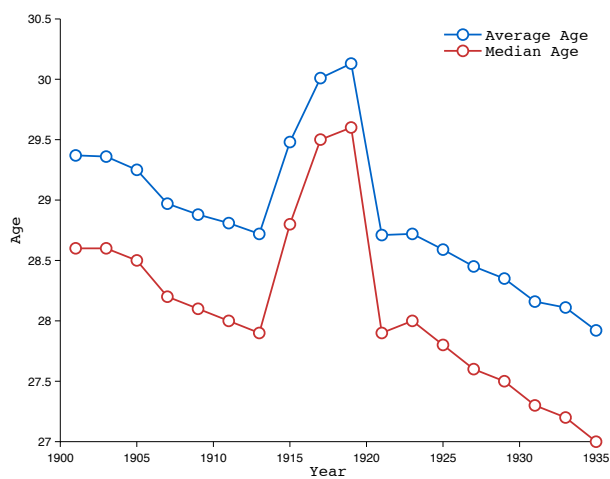
Source: Insee, état civil et recensement de population.

Figure 7: Proportion of Out-of-Wedlock Live Births in France
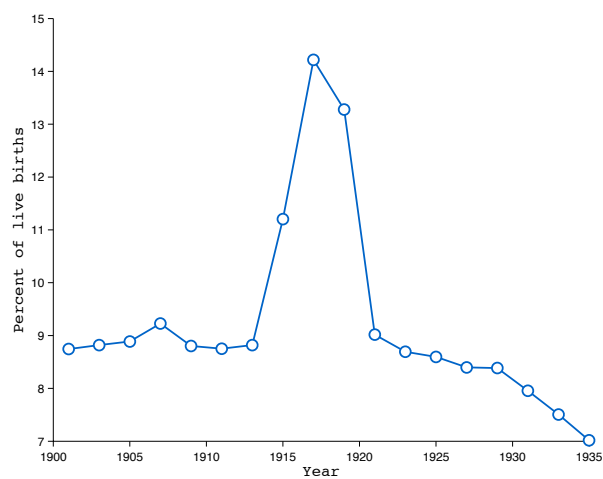
Source: Insee, état civil et recensement de population.

Figure 8: The Contemporaneous Decline in Fertility Caused by a War

$V_1(n+b)$ $U_1(c_{\text{war}})\gamma w^f_{\tau+j-1}$ $U_1(c)\gamma w^f_{\tau+j-1}$

Marginal utility

b
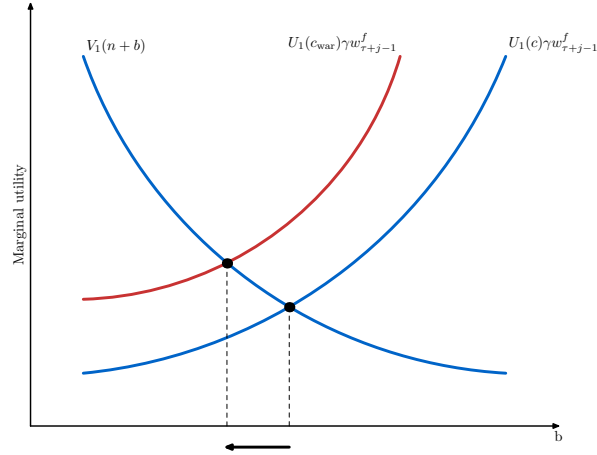
Note: In a war consumption is low, increasing the marginal cost of children.

Figure 9: The Post-war Catch-up in Fertility

$V_1(n+b)$ $V_1(n_{\text{post war}}+b)$ $U_1(c)\gamma w^f_{\tau+j-1}$

Marginal utility

b
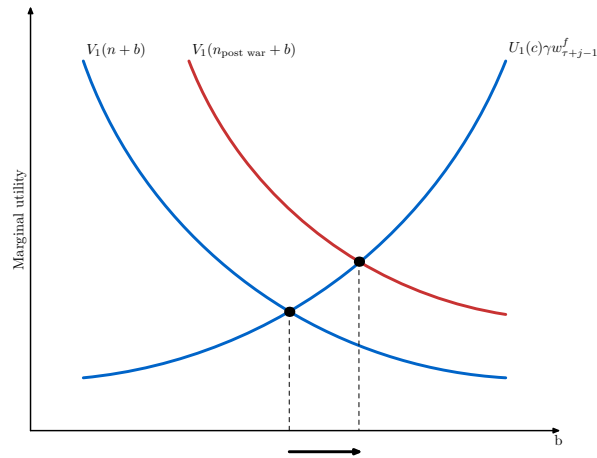
Note: After a war, the stock of children is low, increasing the marginal utility of children.

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Figure 10: Index of Output per Worker in France, 1896–1935
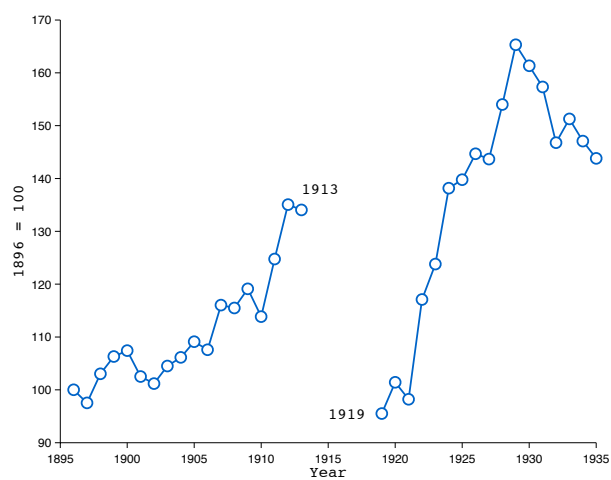
The data is from CEPII. It is available upon request or at can be downloaded at:
http://www.cepii.fr/francgraph/bdd/villa/serlongues/crois.xls
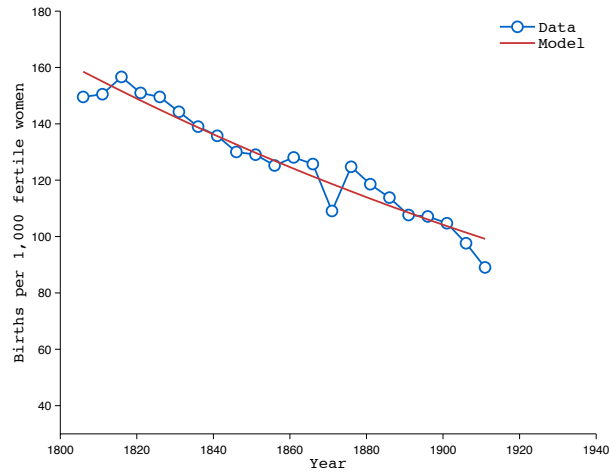
Figure 11: Fertility Rate in France

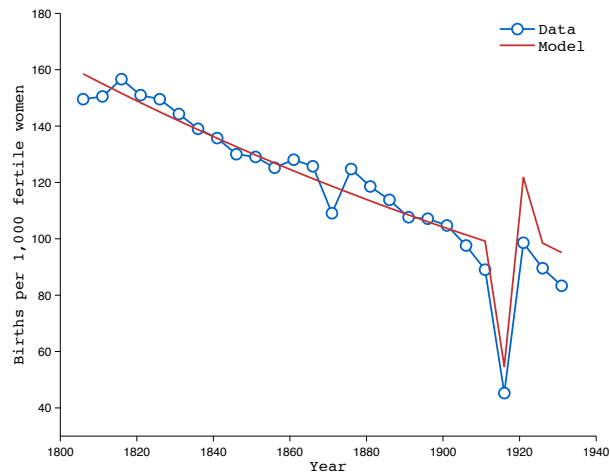Figure 12: Fertility Rate in France, Baseline Experiment ($q = 1$)

Figure 13: Age-Specific Fertility for 2-Adult Households ($q = 1$)
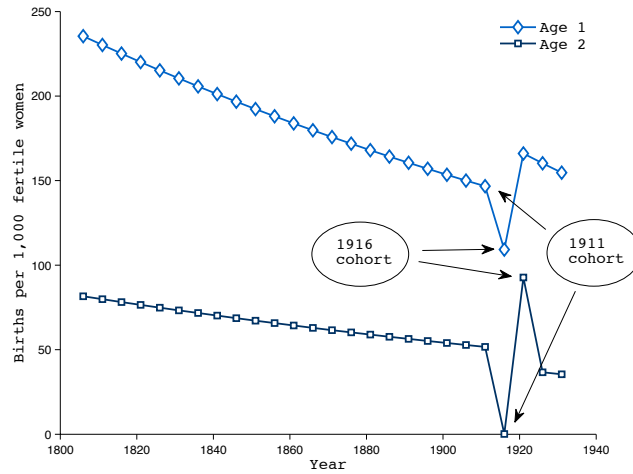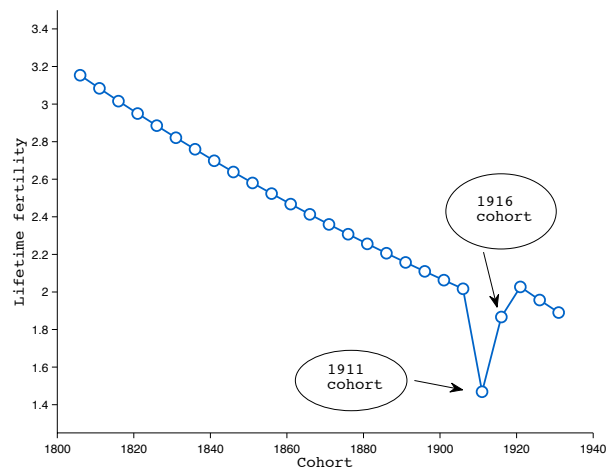

Figure 14: Lifetime Fertility ($q = 1$)

Figure 15: Fertility Rate in France, Counterfactual Experiments ($q = 1$)