The Missing Men

World War I and Female Labor Force Participation*

Jörn Boehnke† Victor Gay‡

April 2018

Abstract

Do sex ratio imbalances affect female labor force participation? Using spatial variation in World War I military fatalities in France, we show that the resulting scarcity of men generated an upward shift in female labor force participation that persisted throughout the interwar period. Increased female labor supply accounts for this result: deteriorated marriage market conditions for single women and negative income shocks to war widows induced many of these women to enter the labor force after the war. In contrast, firms did not increase their demand for female labor to compensate for the scarcity of men.

*We thank Gani Aldashev, Pierre André, Aaron Bodoh-Creed, Jérôme Bourdieu, Louis Cain, Denis Cogneau, Richard Freeman, Claudia Goldin, Richard Hornbeck, Lionel Kesztenbaum, Scott Kominers, Steven Levitt, Magne Mogstad, Natalya Naumenko, Derek Neal, Gilles Postel-Vinay, Maëlys de la Rupelle, Estefania Santacreu-Vasut, Mara Squicciarini, Carlos Villarreal, and Alessandra Voena for fruitful discussions in the process of writing this paper. We gratefully acknowledge the support of the Center of Mathematical Sciences and Applications at Harvard University and the Social Science Division at the University of Chicago during the course of this work.

†Harvard University. Email: boehnke@cmsa.fas.harvard.edu.

‡University of Chicago. Email: victorgay@uchicago.edu (corresponding author).

> "The major fact will be the breakdown of the equilibrium between sexes. There will not be enough suitors for all young women searching for a husband. [...] The prospect of remaining single will induce most young women to worry about getting an occupation to make their living and to be self-sufficient."
>
> Arthur Girault, *La Revue d'Économie Politique*, 1915, *29* (6), pp. 443–444.

Wars, sex-selective abortion, and mass migrations alter gender balances throughout the world. As a result, the ratio of men to women frequently diverges from its natural balance of 106 men for every 100 women.[1] For instance, Klasen and Wink (2003) estimate that about 80 million women were "missing" in China and India in 2000. Imbalances in sex ratios can have far-reaching consequences. Specifically, the shortage of one gender may disrupt marriage market and female labor market conditions both in the short and the long run (Angrist 2002, Abramitzky et al. 2011, Grosjean and Khattar 2016). However, it is often difficult to identify the effects of gender imbalances as well as the mechanisms through which they translate as they are typically the product of factors that also shape labor market structures (Qian 2008, Almond et al. 2013, Carranza 2014). They also generally occur progressively, generating equilibrium responses over time.

We overcome these identification issues by interpreting World War I (WWI) in France as a severe exogenous shock to the adult sex ratio. While WWI ravaged continental Europe between 1914 and 1918, France suffered an especially high death toll relative to other belligerent countries. Because of a universal conscription system, most French male citizens were drafted throughout the war: out of 10 million men aged 15 to 50 before the war, 8 million were drafted in the army. 1.3 million of them died in combat, a military death rate of 16%. As a result, the adult sex ratio dropped from 98 men for every 100 women at the onset the war to 88 men for every 100 women by the end of the war.[2] As shown in Figure 1, it was not until after World War II (WWII) that the pre-WWI adult sex ratio was restored.

Using a unique dataset of military fatalities at the individual level, which we constructed, we examine how this sharp shock affected female labor force participation in the interwar period. Our empirical strategy exploits differential changes in female labor force participation rates before and after WWI across *départements* with varying levels of military death rates.[3]

[1] By *natural balance*, we refer to the sex ratio at birth. It is determined by biology, and excludes the impact of external interventions such as sex-selective abortions (Coale 1991, Klasen and Wink 2003).

[2] The adult sex ratio is usually around 100 men for every 100 women because of the higher natural mortality of boys relative to girls (Klasen and Wink 2003).

[3] French départements are one of the three levels of local government. There were 87 départements before the war, and 90 after the war. The three new départements belonged to Germany before the war. The interwar period is between the end of WWI and the beginning of WWII. This paper focuses on changes in female labor force participation rates in the interwar period for the following reasons. First, it was not

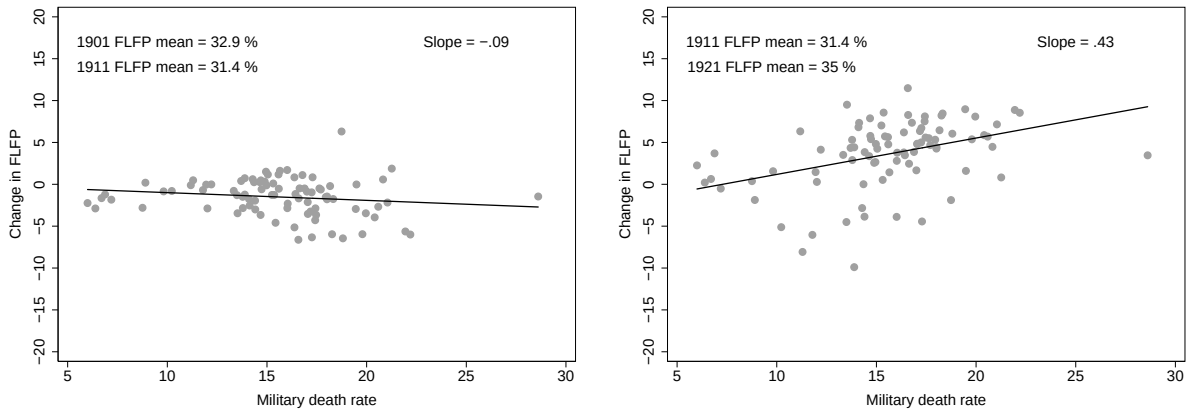
Figure 1. *Adult Sex Ratio (1900–2012)*

Notes. This figure displays the adult sex ratio for the age group 15–50 among the French population. The data are from all the French censuses from 1901 to 2012. The first vertical rays (1914–1918) indicate WWI. The second vertical rays (1939–1945) indicate WWII.

We find that military fatalities shifted female labor force participation upward, an effect that persisted throughout the interwar period. Figure 2 displays the raw relationship between military death rates and changes in female labor force participation rates across départements. While there is no relationship between military fatalities and pre-war changes in female labor force participation between 1901 and 1911 (panel a), each additional percentage point in military death rate is associated with an increase of half a percentage point in female labor force participation rate between 1911 and 1921 (panel b). The baseline difference-in-differences estimates confirm this relationship: in départements that experienced military death rates of 20% rather than 10%—equivalent to switching from the 25th to the 75th percentile of the distribution—female labor force participation was 4 percentage points higher throughout the interwar period, compared to an average participation rate of 31% before the war. That is, these départements experienced an increase in female labor force participation of 12% compared to pre-war levels. At the mean of the data, this implies that losing 10 men during the war induced 2 women to enter the labor force.

Subsequently, we explore the validity of the identifying assumption that counterfactual

until after WWII that the adult sex ratio was restored to its pre-WWI level. Hence, should we observe disruptions resulting from WWI after WWII, the mechanisms at play should be different than the ones we explore here. Second, though much lower, military fatalities from WWII could confound any effect we attribute to WWI. Finally, the measurement of female labor force participation changed after WWII, so that the results may not be comparable across time. Gay (2017) provides an analysis of the long-run impact of WWI military fatalities on female labor force participation.



(a) *Changes in FLFP (1901–1911)* (b) *Changes in FLFP (1911–1921)*

Figure 2. *WWI Military Death Rates and Changes in Female Labor Force Participation*

Notes. FLFP denotes female labor force participation rates in percents. Changes are in percentage points. Each dot represents on of 87 départements.

trends in female labor force participation would have been the same across all départements had they experienced similar military death rates. Military death rates were not randomly distributed across départements as more rural départements experienced more military fatalities. Using an array of historical evidence, we show that this correlation was generated by the policies implemented by the Ministry of War to sustain the industrial war effort. Importantly, this correlation does not invalidate the identification as military death rates were not correlated with pre-war trends in female labor force participation. Nonetheless, to increase the credibility of the identification strategy, we relax the parallel trend assumption in three ways. First, we control for département-specific time trends in female labor force participation. Second, using Bonhomme and Manresa's (2015) grouped fixed effects methodology, we allow for time-varying heterogeneity across groups of départements, where we do not impose any *a priori* structure on group membership. Third, exploiting the fact that the recruitment process of the army led to randomness in military death rates, we use an instrumental variables approach combined with the difference-in-differences strategy. All empirical strategies lead to comparable results, which are in line with the baseline estimates.

We also show that our results are robust to alternative measurements of female labor force participation and military death rates, to spatial correlation across départements, to differential pre-war health conditions and enlistment rates, and to pre- and post-war migration patterns. Moreover, historical data on war destructions and the post-war reconstruction reveal that départements in which war combats occurred do not display a heterogeneous response to military fatalities.

Compared to the well-documented effect of WWII mobilization on female labor force participation in the U.S. (Goldin 1991, Acemoglu et al. 2004, Goldin and Olivetti 2013), the effect we identify is driven by a different mechanism and larger in magnitude.[4] The increase in female labor force participation in the U.S. after WWII was driven by women who entered the labor force *during* the war and continued working afterwards. In contrast, the increase in female labor force participation in France after WWI was driven by women who entered the labor force *after* the war. Supply factors related to changes in marriage market conditions are largely responsible for this pattern. On the one hand, many single women entered the labor force while searching longer for a husband because of the tightness of the post-war marriage market, and, on the other hand, many war widows entered the labor force to compensate for the loss of their husbands' incomes. In contrast, demand factors did not play a significant role. Analyzing changes in female wages before and after the war, we find that female wages strongly declined across all occupations, even in occupations in which men and women are close substitutes. This suggests that firms did not increase their demand for women by substituting male labor for female labor in départements that had high military death rates. Instead, we find that firms increased their stock of physical capital to compensate for the scarcity of men. Finally, using female labor force participation data from 1914 to 1921, we find no evidence that the women who entered the labor force during the war continued working after the war, nor that female labor during the war changed men's beliefs about gender roles in the short run.

The reminder of the paper is organized as follows. Section 1 discusses the related literature, section 2 describes the data and historical context, section 3 presents the main results, and section 4 explores the mechanisms.

1. Related Literature

A broad literature has analyzed the impact of war mobilization and of military fatalities on female labor force participation. It has mostly focused on the impact of WWII mobilization in the U.S., showing that it generated an increase in female labor supply in the 1950s and 1960s (Goldin 1991, Acemoglu et al. 2004, Goldin and Olivetti 2013). In particular, Goldin and Olivetti (2013) find that this effect was primarily driven by higher-educated white married women who were in their twenties during the war. WWII mobilization further affected the type of occupations held by women after the war with a shift toward blue collar occupations

[4]For instance, Acemoglu et al. (2004, p. 528) find that "a 10 percentage point increase in the mobilization rate in the U.S. during WWII is associated with one to three percentage points of additional growth in female labor force participation over [the 1950s]."

(Bellou and Cardia 2016). Relative to this literature, we contribute to the understanding of the effect of wars on subsequent female labor force participation in several ways. Besides shedding light on an alternative mechanism, the extent of WWI military fatalities in France enables us to focus on the impact of a permanent rather than a temporary shortage of men. While the effect of the war was similar in that female labor force participation increased, it was more persistent as it lasted throughout the interwar period. As a comparison, the direct impact of WWII mobilization on female labor in the U.S. faded out in the 1950s and 1960s.[5] Second, the qualitative nature of the effect we find is different: while WWII in the U.S. induced women to enter the labor force because of the disruptions generated by the war-production effort, WWI in France induced women to enter the labor force because of the disruptions to the post-war marriage market generated by the missing men.

Furthermore, we contribute to the literature exploring the effect of sex ratio imbalances on female labor force participation. Economic theories of marriage imply that the scarcity of one gender impacts women's working behavior through its effect on marriage market conditions. For instance, Grossbard's (2014) demand and supply model of marriage imply that the scarcity of men decreases the implicit market price of women's work in the household, thereby decreasing their supply of labor through an income effect.[6] These theoretical predictions have been tested using a variety of sources of variation in sex ratios such as natural fluctuations of cohort sizes or immigration shocks. For instance, exploiting sex ratio differences across cohorts in the U.S. between 1965 and 2005, Amuedo-Dorantes and Grossbard (2007) find a negative correlation between sex ratios and women's labor force participation. Alternatively, Angrist (2002) shows that changes in immigrant sex ratios in the U.S. between 1910 and 1940 induced second-generation migrant women to marry more often, thereby decreasing their labor force participation. In a different setting, Charles and Luoh (2010) find that rising male incarceration rates in the U.S. affected women's working behavior through its impact on marriage market conditions. Compared to this literature, the source of variation in sex ratio we employ enables us to improve upon identification: it is sharper—military fatalities are concentrated within a period of about 4 years—larger in magnitude, and exogenous to the outcome under scrutiny.

We also contribute to the history literature studying the impact of WWI on female labor in France by clarifying the debate between the popular view that the war "liberated women", and the commonly held academic view that the war was a mere "parenthesis" for female

[5]Fernández et al. (2004) nevertheless provide evidence for an indirect effect of WWII mobilization on the working behavior of the daughters in-law of the women working during the war.

[6]Collective models of household labor supply lead to similar conclusions (see, e.g., Chiappori 1992).

labor.[7] Our empirical analysis reveals that the inflow of women in the labor force during the war was indeed only temporary. Nevertheless, we find that the war had a long-lasting impact on female labor through its consequences on post-war marriage market conditions.[8]

2. Data and Historical Context

2.1. Female Labor Force Participation (1901–1936)

We collected female labor force participation data at the département level before and after the war from the seven French censuses from 1901 to 1936.[9] Starting from 1801, the census was carried out every five years except during war years. It was not until the census of 1901 that female labor was consistently recorded. Still, the census of 1901 is not fully comparable to later censuses: while farmers' wives were supposed to be systematically recorded as labor force participants, not all census agents followed this directive (Maruani and Meron 2012, pp. 33–35). For this reason, our analysis focuses on female labor force participation net of farmers' wives. Because these women were systematically classified as farm owners whenever recorded, we avoid a potential measurement concern by subtracting them as nearly all female farm owners were farmers' wives. Moreover, this transformation enables us to focus on paid work. We nevertheless show in Appendix D that all the results in the paper are similar when female farm owners are included in the analysis.

We define female labor force participation as the employed share of the female population aged 15 or older. Table 1 reports average female labor force participation rates between 1901 and 1936. While many women entered the labor force right after the war, many also withdrew a few years after. Because of the economic crisis in the 1930s, pre-war levels in female labor force participation were not recovered at the onset of WWII (Maruani and Meron 2012,

[7]For instance, Françoise Thébaud concludes her seminal study on women during WWI by "[t]he war, which brought hundreds of thousands of women into factories and male sectors, appears at least in part as a parenthesis" (Thébaud 2013, p. 406). Other historians qualify this idea: "[w]ould the war have been a parenthesis in the long history of female labor? This assessment is also debatable, and one can assert from now on that the war accelerated female labor in the industry and in the offices" (Zancarini-Fournel 2005, p. 59). See Downs (1995), Schweitzer (2002), Battagliola (2010), and Maruani and Meron (2012) for other historical accounts of female labor in France throughout the twentieth century. Similarly, economists such as Abramitzky et al. (2011, p. 131) notice that "changes in the female labor market that occurred during the war were reversed upon the end of the war with the return of men to their civilian jobs."

[8]Our dataset of military fatalities also enables us to confirm and extend the results in Abramitzky et al. (2011), who study the short-run effects of military fatalities on the post-war marriage market in France. Appendix I provides precisions on the value added of our data compared to previously available measures of WWI military death rates in France, such as those in Abramitzky et al. (2011) and Vandenbroucke (2014).

[9]The census years are 1901, 1906, 1911, 1921, 1926, 1931, and 1936. Appendix J provides details the sources and definitions of the variables used in the analysis. All the data used in this paper were transcribed from primary sources.

pp. 39–40).[10] Consistent with this picture, historians and economists alike have described the surge in female labor force participation after the war as a mere "parenthesis" in the progress of female labor in France (see footnote 7). Table 1 further motivates our decision to focus on female labor force participation net of female farm owners: while the corrected measure remains stable at 33% between 1901 and 1906, the uncorrected measure displays an increase of 7 percentage points between these two censuses. Given that there was no major shock to labor market conditions between 1901 and 1906, this change can be attributed to the aforementioned measurement inaccuracy. After 1906, the two measures display a constant difference of 19–21 percentage points, suggesting that the corrected measure does not introduce any significant bias.

Table 1
Average Female Labor Force Participation Rates

	1901	1906	1911	1921	1926	1931	1936
FLFP (net of farm owners)	32.9	32.7	31.4	35.0	29.9	30.1	28.1
FLFP (uncorrected)	45.0	51.9	51.5	55.7	49.6	49.4	47.0
Difference	12.0	19.3	20.1	20.7	19.7	19.3	18.9

Notes. This table reports avereage female labor force participation rates across 87 départements—we exclude Bas-Rhin, Haut-Rhin, and Moselle as they did not belong to France until 1918. *FLFP* denotes female labor force participation rates in percents.

2.2. Measuring Military Death Rates at the Département Level

To build a precise measure of military death rates at the département level, we collected individual military records of all the 1.3 million French soldiers who died because of the war from the *Mémoire des Hommes* archive maintained by the French Ministry of Defense.[11] For

[10] Appendix Table A.1 reports summary statistics for male and female labor force participation rates by sector for each census year. Trends in female labor force participation rates mirrored male's, suggesting that labor market conditions across genders were driven by common national trends.

[11] The original archive is accessible at `http://www.memoiredeshommes.sga.defense.gouv.fr`. See Appendix I for more details on this database. The exact number of soldiers who ultimately died as a result of the war is not known with certainty as some soldiers died a few years after the war as a result of injuries or illnesses contracted during the conflict. Nevertheless, the figure of 1.3 million is the consensus among historians. Prost (2008) provides a detailed historical account of the assessment of WWI military fatalities. It is similarly difficult to assess the number of civilian fatalities. Adding up the number of pension requests resulting from civilian fatalities, the civilian victims of the commercial fleet, and the number of victims during the bombings of Paris and cities near the front—Dunkerque, Calais, Béthunes, Arras, Lens, Reims, Pont-à-Mousson, and Nancy—gives a figure of 40,000 (Huber 1931, pp. 310–314).

each deceased soldier, we recorded first name, last name, date of birth, and département of birth.

We define the military death rate in a département as the ratio of the number of deceased soldiers born in the département to the size of its drafted population. We approximate the size of the drafted population by the male population aged 15 to 44 that was residing in the département in 1911, the last census before the war. This approximation is reasonable because, at the onset of the war, the organization of the army relied on an egalitarian and universal conscription system for all French citizens aged 20 to 48. While it was not until 1905 that the universal conscription system was adopted, it applied retroactively to all French citizens.[12] Using the male population aged 15 to 44 in 1911 therefore captures the pool of drafted men.

In Figure 3, we map the distribution of military death rates across 87 départements. The data are missing for the three départements that belonged to Germany before the war—Bas-Rhin, Haut-Rhin, and Moselle (we exclude these départements throughout the analysis). The shaded départements in the North-East experienced war combats on their soil.[13] Military death rates range from 6% in Belfort to 29% in Lozère, with an average of 14% and a standard deviation of 4%. Throughout the paper, we use the following metric to interpret regression results: we compare differences in outcomes across départements that experienced low level of military death rates (10%) and départements that experienced high levels of military death rate (20%). This roughly corresponds to switching from a median département in the "low" group (25th percentile) to a median département in the "high" group (75th percentile).[14]

Measurement inaccuracies could potentially affect our measure of military death rates. First, we determine the number of military fatalities in a département by using soldiers' départements of birth. This measure is inaccurate because a soldier's département of birth may differ from his département of residence, and internal migration flows were not negligible in France at the beginning of the twentieth century—19% of the men aged 15 to 44 were residing outside of their département of birth in 1911. This could be problematic if internal migration flows were correlated with trends in female labor force participation. In Appendix F, we build a measure of military death rates that takes into account these pre-war migration flows by using information on bilateral migration patterns of the male

[12]See the *Journal Officiel de la République Française, Lois et Décrets, 35* (81), pp. 1869–1890, dated March 23rd, 1905. Appendix Table A.2 provides details about the length of military service for each successive military law until WWI.

[13]In Appendix E, we use a wide range of historical data from Michel (1932) to show that war destructions and the intensity of the post-war reconstruction effort in these départements do not affect the results.

[14]This metric is similar to the one used in Abramitzky et al. (2011, p. 135).

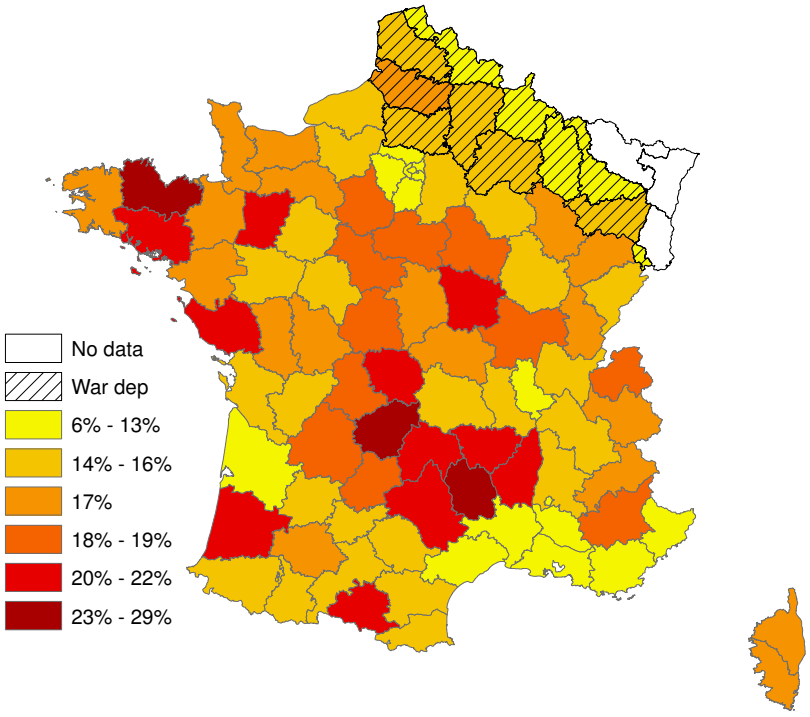


Figure 3. *Distribution of Military Death Rates Across 87 Départements*

population between each pair of départements in 1911. The results obtained when using this corrected measure are similar in magnitude and precision to the ones obtained when using our standard measure.[15]

A second potential concern regards the approximation for the pool of drafted men. We implicitly assume that all men subject to the conscription during the war were recruited by the army, or, equivalently, that the recruitment rate was similar across départements. This is inaccurate as some men were exempted from the conscription due to poor health conditions—78.5% of all men subject to the conscription were recruited by the army at the onset of the war (Huber 1931, p. 93).[16] Using military recruitment data by cohort together with various health measures, we show in Appendix G that the potential concern of differential pre-war recruitment rates across départements does not affect our results.

To illustrate the impact of military death rates on sex ratios, we estimate the following

[15]We also show that a measure based on soldiers' départements of recruitment is contaminated with measurement error as the geography of military recruitment did not overlap département boundaries.

[16]Recruitment rates nevertheless increased as military casualties accumulated throughout the conflict: many men that were previously deemed "unfit" were eventually recalled into the armed forces. For instance, 92% of the cohort aged 20 in 1914 was eventually recruited (Boulanger 2001, pp. 118–128). Another potential concern may be that men under the age of 20 and over the age of 48 could voluntarily enlist in the army, but these were relatively rare cases. For instance, while 26,000 men out of 188,000 conscripts voluntarily enlisted in the army in 1914, they were only 11,000 out of 211,000 to do so in 1915 (Boulanger 2001, pp. 128–136).

first-difference specification:

$$\Delta \texttt{sex\_ratio}_{a,d} = \alpha + \beta\, \texttt{death\_rate}_d + \varepsilon_{a,d}, \tag{1}$$

where $\Delta \texttt{sex\_ratio}_{a,d}$ denotes the change in sex ratio between 1911 and 1921 for age group a in département d, and $\texttt{death\_rate}_d$ the military death rate in département d. Table 2 reports the results. Because drafted men were 20 to 48 during the war, age groups 25–49 experienced the strongest declines in sex ratios. For instance, a 10 percentage point increase in military death rates is associated with a decrease of 6 percentage points in the sex ratio of the age group 30–34. As a result, the sex ratio among this age group dropped from 100 in 1911 to 82 in 1921.

Table 2
The Impact of Military Death Rates on Sex Ratios (1911–1921)

Age group:	20–24	25–29	30–34	35–39	40–44	45–49	50–54
Death rate	0.61	-0.46**	-0.58***	-0.37***	-0.32**	-0.09	0.00
	[0.95]	[0.19]	[0.13]	[0.13]	[0.13]	[0.14]	[0.12]
Départements	87	87	87	87	87	87	87
R^2	0.006	0.061	0.170	0.089	0.101	0.008	0.000
Mean sex ratio 1911	107	99	100	100	99	99	97
Mean sex ratio 1921	86	80	82	84	91	96	95

Notes. This table reports the OLS coefficients from estimating specification 1. The dependent variable is the change in sex ratio between 1911 and 1921 for a given age group in percentage points. Sex ratios are defined as the ratio of the male population to the female population in percents. Robust standard errors are in brackets.
*** Significant at the 1 percent level. ** Significant at the 5 percent level.

2.3. Sources of Variations in Military Death Rates

In this section, we explore the sources of variation in military death rates across départements. We show that military death rates were not randomly distributed but instead determined by the geographical organization of the army at the beginning of the war and by demographic and economic characteristics. Overall, more rural départements experienced more military fatalities. This correlation was generated by the policies implemented by the Ministry of War to draw industrial workers from the battlefield into war factories in order to sustain the industrial war effort. Nevertheless, the distribution of military death rates was not correlated with pre-war trends in female labor force participation, giving us confidence in the validity on the identifying assumption of the difference-in-differences strategy.

2.3.1. The Geography of the Military

The first source of variation in military death rates across départements stems from the geography of the organization of the army. In 1914, the army was organized in 21 military regions and 2 specific bureaus for Paris and Lyon.[17] Both the recruitment of soldiers and the constitution of military units were based on these military regions: at the beginning of the war, soldiers were assigned to military units that were constituted by soldiers from the same military region. As a result, soldiers from the same military region were initially sent to the same battle fields according to the plan of mobilization designed in 1912, the *Plan XVII* (Joffre 1932). This plan assigned each military unit to a battle front in the case of an attack by German troops. Gonzalez-Feliu and Parent (2016) show that the allocation logic of the troops at the beginning of the war was the outcome of an optimization problem in which the objective of the military command was to minimize the travel time of the troops between their military region of origin and the front, with the railroad network as the main constraint.[18] However, as military casualties accumulated, the military command changed its affectation policy: after only 5 months into the war, soldiers were allocated to any military unit based on each unit's needs in soldiers. As a result, troops from different military regions were increasingly mixed together starting January 1915.[19]

This military organization has two consequences regarding variations in military death rates across départements. First, départements that did not belong to the same military region had different military death rates because their troops were assigned to different battle fields at the beginning of the war, with presumably different levels of casualties. Second, départements that belonged to the same military region could have had similar military death rates for the same reason. The latter might reduce the extent of the variation in military death rates across départements that were within the same military region. However, the correlation of military death rates across départements within the same military region is small (0.12), as soldiers from different military regions were mixed into the same military units soon after the beginning of the war.

[17]The basis of this system was given by the law of the general organization of the army of July 24th, 1873. The geography of the army was then only marginally readjusted until WWI. The exact geography that prevailed in August 1914 was fixed by the law of December 22nd, 1913 (Boulanger 2001, pp. 16–24). See the *Journal Officiel de la République Française, Lois et Décrets, 45* (349), pp. 11009–11010, dated December 24th, 1913.

[18]See Joffre (1932) and Le Hénaff (1922) for a historical account of the preparation and application of the transportation plan of the troops along the lines of the Plan XVII.

[19]This change in affectation policy was allowed by the *circulaire* of December 6th, 1913, in the case of war time (Boulanger 2001, p. 253).

2.3.2. Demographic and Economic Factors

We now explore how pre-war economic and demographic characteristics help explain variations in military death rates across départements. We divide départements into three groups of 29 départements with low, medium, and high levels of military death rates, and we regress pre-war characteristics on group membership indicators.[20] We report the results in Table 3. Column 1 reports means of pre-war characteristics, and columns 2 and 3 coefficients on the medium and high group membership indicators. By construction, these represent the difference between the relevant group mean and the low group mean. Column 4 reports the difference in means between the high and the medium group.

A clear pattern emerges: more rural départements experienced more military fatalities. The rurality of a département can be captured by two characteristics: the *share of rural population* (the share of population that resides in cities smaller than 2,000 inhabitants, as defined by the censuses), and the *share of the residing population born in the département*.[21] Finally, départements with higher military death rates had lower female labor force participation rates before the war. These differences in levels across départements will not affect the identification as they will be absorbed by département fixed effects.

To explore this pattern in more details, we regress military death rates on these pre-war characteristics. Selected estimates are reported in Table 4.[22] Départements with higher military death rates had lower female labor force participation rates before the war (column 1). Moreover, more rural départements had more military fatalities (columns 2 and 3). The share of rural population and the share of the residing population born in the département explain a large share of the variation in military death rates across départements, as they respectively explain 69% and 62% of its variance. When including all the variables, only these two characteristics exhibit statistical significance at conventional levels (column 4). Finally, the corresponding coefficients barely change either when including (column 5) or excluding (column 6) female labor force participation from the regression. Finally, we include 20 region fixed effects to effectively compare neighboring départements (column 7). Again, the results are similar. The share of rural population together with the share of the residing population

[20]We estimate the following specification: $\mathbf{X}_{d,1911} = \alpha + \beta_m \, \texttt{medium}_d + \beta_h \, \texttt{high}_d + \varepsilon_d$, where $\mathbf{X}_{d,1911}$ corresponds to characteristic $\mathbf{X}$ of département d in 1911, $\texttt{medium}_d$ is an indicator for département d being in the medium group, and $\texttt{high}_d$ an indicator for département d being in the high group. The low military death rates group is the excluded category.

[21]The *average personal wealth*, the *share of active population working in agriculture*, or the *share of cultivated land* also capture some aspects of rurality, but all the variation in these variables across départements is captured by the *share of rural population* and the *share of the residing population born in the département*. While a higher share of the residing population born in the département may mean either more immigration or more emigration, the later is the case. See Tugault (1970) and White (1989) for more details on internal migrations in France in the early twentieth century.

[22]The full set of estimates is available in Appendix Table A.3.

Table 3
Pre-War Characteristics by Level of Military Death Rate

Military death rate:	All	Relative to low: Medium	Relative to low: High	Difference (3) - (2)
	(1)	(2)	(3)	(4)
Death rate (%)	15.6	4.2***	7.7***	3.4***
	(3.8)	[0.5]	[0.7]	[0.5]
FLFP (%)	31.4	-1.9	8.8***	-5.0**
	(8.9)	[2.3]	[2.2]	[2.2]
Demographic characteristics				
Population (thousands)	450	-293.44**	-334.14**	-40.70
	(468)	[142.35]	[142.00]	[36.02]
Population density (per km^2)	166	-335	-343	-7
	(908)	[291]	[291]	[5]
Share rural population (%)	66.9	21.5***	30.2***	8.8***
	(17.7)	[3.8]	[3.8]	[1.7]
Share born within département (%)	79.8	11.4***	17.2***	5.8***
	(11.6)	[2.8]	[2.8]	[1.4]
Age	32.4	0.5	-0.4	-0.9*
	(2.0)	[0.5]	[0.5]	[0.5]
Height (cm)	166.2	-0.30	-1.13***	-0.83***
	(1.2)	[0.26]	[0.29]	[0.29]
Economic characteristics				
Share in industry (%)	31.5	-10.5***	-17.1***	-6.6***
	(11.2)	[2.7]	[2.5]	[1.7]
Share in agriculture (%)	48.8	16.6***	26.9***	10.3***
	(15.5)	[3.3]	[3.1]	[1.9]
Road density (km per km^2)	1,283	-102	-193**	-91
	(342)	[94]	[89]	[81]
Rail density (km per km^2)	1.5	-1.1	-1.3*	-0.2**
	(2.3)	[0.7]	[0.7]	[0.1]
Share cultivated land (%)	44.3	3.7	1.3	-2.4
	(17.0)	[4.4]	[4.7]	[4.4]
Personal wealth (francs per inhabitant)	3,639	-1,006	-2,235***	-1,229***
	(2,384)	[652]	[648]	[424]
Banking deposits (francs per inhabitant)	12.7	-2.5	-2.1	0.4
	(5.8)	[1.7]	[1.7]	[1.1]
Direct taxes (francs per inhabitant)	23.7	-4.6**	-9.9***	-5.3***
	(8.1)	[1.9]	[1.9]	[1.8]
Share read and write (%)	84.7	-1.8	-7.2***	-5.4**
	(7.7)	[1.7]	[1.8]	[2.1]
Share primary education (%)	61.1	1.6	-9.0**	-10.7***
	(14.6)	[3.3]	[3.7]	[4.0]
Other characteristics				
Distance to war (km)	322	30	106**	76
	(205)	[60]	[53]	[46]
Share students in religious schools (%)	3.0	-0.8	0.2	1.0
	(3.4)	[0.7]	[1.0]	[1.0]
Vote in 1905 (%)	61.4	-5.9	-2.6	3.3
	(32.5)	[8.9]	[7.9]	[9.0]
Turnout in 1914 (%)	76.9	0.4	-0.0	-0.4
	(5.6)	[1.3]	[1.6]	[1.5]

Notes. Column 1 reports mean values for 87 départements. Standard deviations are in parenthesis. Columns 2 and 3 report the OLS estimates from regressing pre-war characteristics on indicators for being a medium ($\widehat{\beta}_m$) and a high ($\widehat{\beta}_h$) military death rates département following the specification in footnote 20. Column 4 displays the difference between estimates in columns 3 and 2. Robust standard errors are in brackets. Each group contains 29 départements. See Appendix J for details about variable sources and definitions.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

born in the département together explain 74% of the variation in military death rates across départements. We will use these two variables as the time-varying control variables in the analysis.

Table 4
OLS Estimates of Military Death Rates on Pre-War Characteristics

Dependent variable:	Military death rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FLFP	-0.15***			-0.06	0.03		
	[0.05]			[0.07]	[0.03]		
Rural		0.18***		0.11***	0.12***	0.12***	0.10***
		[0.02]		[0.03]	[0.01]	[0.01]	[0.02]
Born in dép.			0.26***	0.15***	0.13***	0.12***	0.18***
			[0.03]	[0.04]	[0.03]	[0.03]	[0.03]
Demographic characteristics	No	No	No	Yes	No	No	No
Economic characteristics	No	No	No	Yes	No	No	No
Other characteristics	No	No	No	Yes	No	No	No
Region FE	No	No	No	No	No	No	Yes
Départements	87	87	87	87	87	87	87
R^2	0.120	0.686	0.624	0.790	0.739	0.739	0.765

Notes. This table reports the OLS estimates from regressing military death rates on pre-war characteristics. *FLFP* is the female labor force participation rate in percents. *Rural* is the share of rural population in percents. *Born in dép* is the share of the residing population born in the département in percents. *Demographic*, *Economic*, and *Other* characteristics are all other characteristics in Table 3. Robust standard errors are in brackets.
*** Significant at the 1 percent level.

There are two main reasons for the strong correlation between military death rates and rurality. First, as the war lasted longer than anticipated, the military command realized that its plan for supplying weapons and machinery to the troops was highly insufficient (Porte 2005, pp. 73–82). For instance, the plan of military mobilization did not mention any production of new military equipment, providing only 50,000 workers allocated across thirty war factories (Porte 2006, p. 26). In fact, it was not until January 1917 that a proper ministry of armament was created.[23] To cope with the ongoing war effort in conjunction with the lack of available civilian labor and the German occupation of industrial départements in the North-East, the Ministry of War issued a law in August 1915 to withdraw soldiers with manufacturing skills from the front lines, and allocate them to war factories.[24] As a

[23]The *Ministère de l'Armement* was created by the decree of December 31st, 1916 (*Journal Officiel de la République Française, Lois et Décrets*, *49* (1), pp. 18–19, dated January 1st, 1917).

[24]The law Dalbiez of August 17th, 1915, stipulates the following. "The Ministry of War is authorized to

result, up to 560,000 soldiers who should have been on the front lines were working in war factories during the conflict.[25] Furthermore, in 1916, the military command also started to allocate some of its soldiers into mines to increase steel production. Thus, soldiers from more industrial départements, or, equivalently, from less rural ones, had a lower chance of dying in combats.[26] Second, compared to the urban population, the rural population was less educated, and thus lacked the skills to be hired by various military administrations operating far from battle zones. As a result, administrative jobs were mostly given to soldiers from urban areas (Ridel 2007).

Military death rates and migration patterns are also correlated as captured by the share of the residing population born in the département. To explore this in more details, we build a more direct measure of migration flows at the département level by computing the share of the population that was "in excess" in 1911 based on yearly flows of births and deaths since 1901.[27] When regressing military death rates on this measure, we find that départements that experienced more migration outflows had higher military death rates. Moreover, the share of the residing population born in the département is a strong predictor of these migration outflows: regressing the population in excess on the share of the residing population born in the département yields a coefficient of -0.36, with a standard error of 0.04, and an R^2 of 79%. This confirms our interpretation that emigration départements had more military fatalities.

Overall, the relationship between military death rates and measures of rurality can be thought of as the result of the policies implemented by the Ministry of War to sustain the industrial war effort. We interpret the residual variation in military death rates as non-systematic, and related to the randomness at which soldiers encountered violence on the battlefield. Many war novels describe this phenomenon. Among others, Erich Maria Remarque writes: "It is by chance that I remain alive, just as it is by change that I can be hit. In the bombproof shelter, I can be torn to pieces, while in the open under ten hours of

allocate to corporations, factories, and mines working for the national defense men belonging to a mobilized or mobilizable age class, industrial managers, engineers, production managers, foremen, workers, and who will justify to have practiced their job for at least a year in those corporations, firms and mines, or in comparable corporations, firms, and mines" (art. 6, *Journal Officiel de la République Française, Lois et Décrets*, *47* (223), pp. 5785–5787, dated August 19th, 1915).

[25]We provide a detailed account of the number of mobilized soldiers outside of armed services throughout the war in Appendix Table A.4.

[26]Lower military death rates of industrial départements induced by the Law Dalbiez were mitigated by the mobilization of soldiers into harvesting from 1917. This was authorized by the law Mourier of February 20th, 1917 (*Journal Officiel de la République Française, Lois et Décrets*, *49* (51), p. 1408, dated February 21st, 1917).

[27]The share of population in excess in département d in 1911 is calculated as $\left[\texttt{population}_{d,1911} - \left(\texttt{population}_{d,1901} + \sum_{t=1901}^{1911} \texttt{births}_{d,t} - \sum_{t=1901}^{1911} \texttt{deaths}_{d,t}\right)\right] / \texttt{population}_{d,1911} \times 100$.

the most violent bombardments, I may not receive a scratch" (Remarque 1929).[28]

Correlations between pre-war characteristics in levels and military death rates need not threaten the identification as long as the distribution of military death rates is not correlated with trends in female labor force participation. Regressing military death rates on changes in female labor force participation before the war reveals that départements with higher military death rates were experiencing a slight relative decline in female labor force participation before the war (columns 1 and 4 of Table 5). However, these coefficients are not significant, and would bias the results downward. As described earlier, départements with higher military death rates were experiencing migration outflows before the war. Labor market structures of these départements was slowly changing as well: the size of their industrial sector was slowly decreasing, explaining the relative decline in female labor force participation in these areas. As a result, controlling for changes in the share of rural population and changes in migration flows, the correlation between pre-war trends in female labor force participation and military death rate becomes even weaker (columns 3 and 6). Hence, these slight pre-war differential trends in female labor force participation do not invalidate the identification. We later substantiate this claim with a battery of tests to relax the parallel trend assumption.

Table 5
OLS Estimates of Military Death Rates on Pre-War Trends

Dependent variable:	Military death rate					
	A. 1901–1911			B. 1906–1911		
	(1)	(2)	(3)	(4)	(5)	(6)
Change in FLFP	-0.27		-0.20	-0.36		-0.32
	[0.17]		[0.14]	[0.30]		[0.27]
Change in Rural		0.43**	0.41**		0.61***	0.59***
		[0.19]	[0.19]		[0.22]	[0.22]
Change in Born in dép.		0.74***	0.72***		0.92***	0.92***
		[0.20]	[0.21]		[0.22]	[0.21]
Départements	87	87	87	87	87	87
R^2	0.025	0.201	0.214	0.014	0.203	0.213

Notes. This table reports the OLS estimates from regressing military death rates on pre-war trends. All the variables are first-differenced between 1911 and 1901 (columns 1–3), or between 1911 and 1906 (columns 4–6). *FLFP* is the female labor force participation rate in percents. *Rural* is the share of rural population in percents. *Born in dép* is the share of the residing population born in the département in percent. Robust standard errors are in brackets.
*** Significant at the 1 percent level. ** Significant at the 5 percent level.

To make these changes more apparent, we report in Figure 4 relative trends in female

[28]Cited in Guillot and Parent (2015, p. 2).

labor force participation across the three groups of départements between 1901 and 1936, where we normalize female labor force participation rates to 100 in 1911. This figure reveals that départements with higher military death rates experienced a relative increase in female labor force participation after the war. It also confirms that there were no clear differential trends in female labor force participation across départements with varying levels of military death rates in the pre-war period.

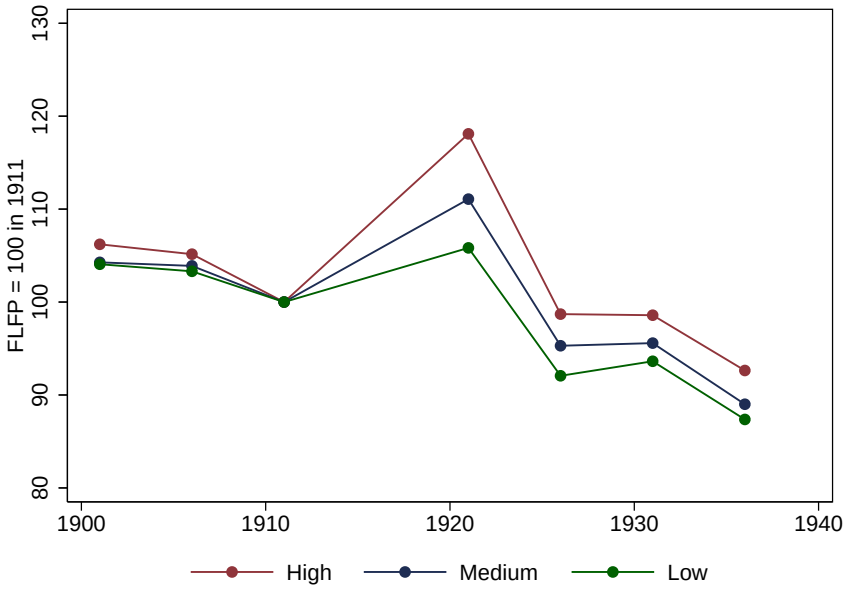


Figure 4. *Relative Trends in Female Labor Force Participation (1901-1936)*

Notes. This figure displays relative trends in female labor force participation between 1901 and 1936 across groups of 29 départements with high, medium, and low military death rates. Female labor force participation (*FLFP*) is normalized to 100 in 1911.

3. The Missing Men and Female Labor Force Participation

3.1. Baseline Difference-in-Differences Estimates

To analyze the effect of military fatalities on female labor force participation in the interwar period, we use a difference-in-differences strategy. Identification stems from relative changes in female labor force participation rates across départements with varying levels of military death rates. We estimate the following specification:

$$\texttt{FLFP}_{d,t} = \beta\, \texttt{death\_rate}_d \times \texttt{post}_t + \boldsymbol{\theta}'\, \mathbf{X}_{d,t} + \boldsymbol{\gamma}_d + \boldsymbol{\delta}_t + \varepsilon_{d,t}, \tag{2}$$

where $\texttt{FLFP}_{d,t}$ is the female labor force participation rate in département d in year t, $\texttt{death\_rate}_d$ is the military death rate in département d, $\texttt{post}_t$ is an indicator variable equal to 1 if $t > 1918$, $\boldsymbol{\gamma}_d$ are département fixed effects, and $\boldsymbol{\delta}_t$ are census-year fixed effects. $\mathbf{X}_{d,t}$ is a vector containing the two time-varying characteristics described earlier: the share of rural population and the share of the residing population born in the département.

Département fixed effects $\boldsymbol{\gamma}_d$ control for département-specific unobservable characteristics that are fixed over time and may generate systematic differences in levels of female labor force participation. For instance, some départements may have more traditional views about gender roles than others and therefore display systematically lower female labor force participation rates. Census-year fixed effects $\boldsymbol{\delta}_t$ control for aggregate-level shocks that are common to all départements. For instance, labor markets throughout the country were affected by the Great Depression between 1926 and 1936 (Maruani and Meron 2012, pp. 39–40). We include changes in rurality and in migration flows as covariates as they could be correlated with changes in female labor force participation.[29]

We report the baseline estimates in Table 6. In départements that experienced military death rates of 20% rather than 10%, female labor force participation was 3.7 percentage points higher in the interwar period, compared to an average of 31.4% in 1911 (column 1). This corresponds to an increase of 12% in female labor force participation rates. Put differently, losing 10 men during the war induced 2 women to enter the labor force on average.[30] Controlling for changes in the share of rural population and the share of the residing population born in the département barely affects the results (columns 2–4). We also find that military fatalities had no effect on male labor force participation (Appendix Table A.5).[31]

[29]Many of the other covariates that are available for this time period are likely to be directly affected by military fatalities, such as changes in local labor market structures or changes in population levels. As a result, we do nots include them as controls in the regression because they could confound the post-treatment relationship between military fatalities and female labor force participation. Although that the measures of rurality could also be impacted by military fatalities, we show that the estimates barely change when including these controls.

[30]For each département, we compute two quantities: the number of military fatalities corresponding to one percentage point in military death rates, and the number of working women corresponding to a 0.37 percentage point increase in female labor force participation rates. We then use a product rule and average the results across départements.

[31]To better understand the extent to which each département contributes to the estimates, we apply Aronow and Samii's (2016) procedure to uncover the "effective sample" used in the regression. This procedure generates regression weights by computing the relative size of the residual variance of the treatment variable for each unit in the sample. We find that all départements contribute broadly equally to construct the estimates, although départements that experienced less migration flows during this period have a slightly larger weight in the regression (Appendix Table A.6).

Table 6
The Impact of WWI Military Fatalities on Female Labor Force Participation
Baseline OLS Estimates

Dependent variable:	Female Labor Force Participation			
	(1)	(2)	(3)	(4)
Death rate × post	0.37***	0.35***	0.37***	0.35***
	[0.08]	[0.07]	[0.07]	[0.07]
Rural	No	Yes	No	Yes
Born in dép.	No	No	Yes	Yes
Département FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	609	609	609	609
Départements	87	87	87	87
Within R^2	0.578	0.579	0.579	0.581
1911 mean	31.4	31.4	31.4	31.4

Notes. This table reports the OLS coefficients from estimating specification 2. The dependent variable is female labor force participation in percents. The census years are 1901, 1906, 1911, 1921, 1926, 1931, and 1936. *Rural* is the share of rural population in percents. *Born in dép.* is the share of the residing population born in the département in percents. Standard errors are in brackets, and are clustered at the département level. *** Significant at the 1 percent level.

3.1.1. Year-Specific Difference-in-Differences Estimates

We now relax the assumption that the effect of military fatalities was constant across time by estimating year-specific difference-in-differences coefficients. The specification includes leads and lags to assess the plausibility of the parallel trends assumption:

$$\texttt{FLFP}_{d,t} = \sum_{\substack{t=1901 \\ t\neq 1911}}^{1936} \beta_t \, \texttt{death\_rate}_d \times \texttt{year}_t + \boldsymbol{\theta}' \, \mathbf{X}_{d,t} + \boldsymbol{\gamma}_d + \boldsymbol{\delta}_t + \varepsilon_{d,t}, \tag{3}$$

where we exclude the year 1911, and where $\texttt{year}_t$ is an indicator variable for each year between 1901 and 1936. We plot the estimates in Figure 5.[32] They are stable throughout the interwar period, suggesting that the impact of WWI military fatalities on female labor force participation was persistent. Again, adding the control variables barely affects the results.

[32]The complete set of results is available in Appendix Table A.7.

The coefficients on pre-war years are not significant, suggesting that differential trends in pre-war female labor force participation are not driving the results. They are nonetheless slightly positive: for instance, the baseline coefficient on the lead of 1906 is 0.04, with a standard error of the same magnitude. This implies that départements that experienced higher military death rates had a relative downward trend in female labor force participation before the war, which could bias the estimates downward. Following the analysis in above, we interpret this potential downward bias as the result of the correlation between unobservable determinants of migration patterns and pre-war trends in female labor force participation. Below, we discuss an alternative measure of military death rates that corrects for these pre-war migration patterns, and show that they do not drive the results.

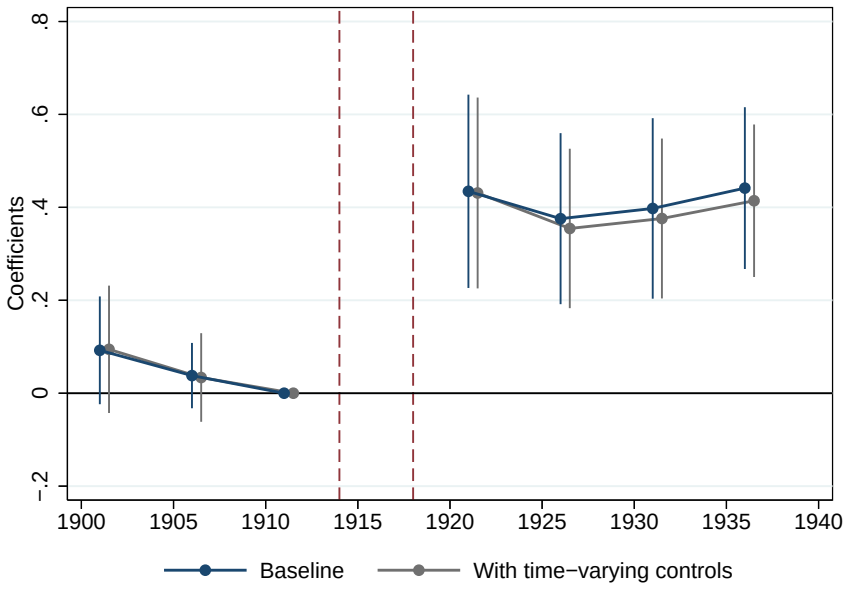


Figure 5. *The Impact of WWI Military Fatalities on Female Labor Force Participation Year-Specific OLS Estimates*

Notes. This figure reports the year-specific OLS estimates of columns 1 and 4 of Appendix Table A.7. The time-varying controls include the share of rural population and the share of the residing population born in the département. Vertical lines represent 95% confidence intervals around the estimates.

3.1.2. Estimates by Sector of Activity

Decomposing the response of female labor to military fatalities by sector of activity, we find that most of the effect identified stems from women entering the industrial sector and the domestic services sector. Compared to pre-war levels, the magnitude of the impact is similar across both sectors: in départements that experienced military death rates of 20% rather than 10%, female labor force participation increased by 20% in both sectors compared to

pre-war levels. The analysis is presented in Appendix B.

3.2. Relaxing the Parallel Trends Assumption

We now present three ways of relaxing the parallel trends assumption—the full set of results from these analyses is reported in Appendix C.

3.2.1. Département-Specific Time Trends

First, we verify that differential trends in female labor force participation do not drive the results by controlling for département-specific linear time trends (Appendix C.1). The point estimates are significant at the 1% level and larger than the baseline at 0.40 (relative to 0.35), suggesting that pre-war differential trends in female labor force participation generated a slight downward bias. Adding quadratic, cubic, or quartic time trends generates similar insights—the point estimates in these cases are close to 0.47.

3.2.2. Grouped Fixed Effects

Second, we inspect the robustness of the baseline specification to allowing for time-varying heterogeneity across groups of départements (Appendix C.2). In particular, we relax the assumption that time fixed effects are common to all départements. Using Bonhomme and Manresa's (2015) grouped fixed effects algorithm, we do not impose any *a priori* structure on the group assignment. Allowing for heterogeneity in the time pattern of female labor force participation across up to 10 groups of départements generates point estimates close to 0.3, suggesting that the parallel trends assumption is reasonable in this context.

3.2.3. Instrumental Variables Strategy

Third, we integrate an instrumental variables strategy within the difference-in-differences framework. In particular, we leverage on some exogenous variation in military death rates that results from the recruitment process of the army (Appendix C.3). At the onset of the war, the active army was constituted with four age cohorts: the men aged 20 to 23.[33] We designate an age cohort by the year in which it was recruited by the army, i.e., the year that cohort attained age 20. For instance, we designate the cohort that was born in 1894 as the *class of 1914*. In 1914, the active army was constituted by the classes of 1911 to 1914: while the class of 1914 had just been recruited, the class of 1911 had just finished its three years of

[33]Following the military conscription law of 1913, the general army was divided into four armies: the active army, composed by the age classes currently doing their military service, the reserve of the active army, the territorial army, and the reserve of the territorial army. Appendix Table A.2 provides for the length of service in each of these armies.

military training and was about to be transfered to the reserve of the active army. As a result, men that belonged to the classes of 1911 to 1914 had different levels of military training at the onset of the war. They were nevertheless sent to the same battlefields, within the same military units. Intuitively, men with more military training should be more efficient on the battlefield and die at lower rates. This is indeed what we find in the data: the contribution of each class to military fatalities is monotonically increasing from the class of 1911 to the class of 1914.[34] We argue that these differences are essentially due to differences in military training. We build on these discontinuities and create three instruments, each instrument representing the relative size of a cohort relative to the following cohort in 1911. These instruments are uncorrelated with pre-war trends in female labor force participation but strongly correlated with military death rates. Overall, instrumenting military death rates in equation 2 with the relative size of consecutive cohorts results in point estimates that are larger than the baseline at 0.54 (relative to 0.35), again revealing that pre-war differential trends in female labor force participation created a slight downward bias.

3.3. Other Robustness Checks

In this section, we perform additional robustness checks. When appropriate, we compare the results of these robustness checks against the main result, the estimate of 0.35 reported in column 4 of Table 6.

3.3.1. Alternative Measure of Female Labor Force Participation

Wives of farmers were inconsistently recorded as labor force participants across départements in the census of 1901. Moreover, they accounted for almost all female farm owners. We therefore systematically excluded female farm owners from the data in order to properly examine pre-war trends in female labor force participation. In Appendix D, we replicate the main analyses of the paper when including these women in the measure of female labor force. We find slightly larger estimates due to some women entering the agricultural sector upon becoming farm owners following the death of their husbands or their sons—the point estimate increases from 0.39 with the standard measure of female labor force participation (when excluding the year 1901) to 0.45 when including female farm owners.

[34]More precisely, the class of 1911 contributed 5.7% to overall military fatalities, the class of 1912 contributed 6.2%, the class of 1913 contributed 6.5%, and the class of 1914 contributed 6.7%.

3.3.2. War Départements

War combats occurred on the territory of eleven départements in the industrial North-East (see Figure 3). These départements suffered from minor destructions to total devastation. The French State, through the *Ministère des Régions Libérées*, provided a large amount of funds to help the reconstruction effort throughout the interwar period (Michel 1932, pp. 549–558). It could be problematic if military fatalities were correlated with war destructions or with the intensity of the reconstruction effort. On the one hand, the loss of physical capital entailed by war destructions could imply a decline in the demand for labor relative to other départements. A positive correlation between military fatalities and war destructions could therefore bias the estimates downward. On the other hand, the reconstruction effort financed by the State could imply an increase in the demand for labor relative to other départements. A positive correlation between military fatalities and the intensity of the reconstruction effort could therefore bias the estimates upward. The net impact of this process would then depend on the relative intensity of war destructions vis-à-vis the reconstruction effort, and the extent of the correlations with military fatalities.

In Appendix E, we propose two strategies to cope with this potential problem. First, we replicate the analysis when excluding these eleven départements. Second, we collect data about the intensity of war destructions and the reconstruction effort in these départements from Michel (1932) and directly check whether military fatalities are correlated with these measures. The results for both strategies imply that war départements are not driving the results. First, excluding these départements from the analysis only marginally affects the estimates: the point estimate decreases from 0.35 to 0.28, mostly because the effect of military fatalities on female labor force participation disproportionately affected the industrial sector (see Appendix B), and these départements were predominantly industrial.[35] Second, we find no correlation between military death rates and war destructions or the intensity of the reconstruction effort.

3.3.3. Correcting Military Death Rates for Pre-War Migration Patterns

We determine the number of military fatalities in a département by using soldiers' départements of birth. Pre-war migration patterns could introduce some bias in this measure as 19% of the men subject to conscription during the war were living outside of their département of birth in 1911. This could be problematic if men born in rural départements systematically migrated to urban départements. In this case, military death rates in urban départements would be understated and those in rural départements, overstated. Given that female labor

[35] 29% of the male active population worked in the industrial sector in départements not directly affected by war combats in 1911 compared to 49% in the départements directly affected by war combats.

force participation was more responsive in areas with larger pre-war industrial and domestic services sectors, unobserved pre-war migration patterns could introduce downward bias in the baseline estimates.

To assess the robustness of the results to unobserved pre-war migration patterns, we construct in Appendix F an alternative measure of military death rates which takes into account bilateral migration flows across départements in the census of 1911. We replicate the main results of the paper, and find slightly larger estimates—the point estimate increases from 0.35 with the standard measure of military death rates to 0.55 with the measure correcting for bilateral migration flows.[36]

3.3.4. Pre-War Health Conditions and Differential Enlistment Rates

Using the male population aged 15 to 44 in 1911 may not adequately capture the pool of drafted men as not all men subject to military conscription were enlisted in the army—78.5% of the men aged 20 to 48 were enlisted at the beginning of the war (Huber 1931, p. 93). The reminder of this age group was not enlisted, mostly due to poor health conditions. Given that health conditions partially determine a soldier's ability on the battlefield, départements with worse pre-war health conditions could have experienced higher military death rates. If this were the case, and if we were unable to control for these differences in pre-war health conditions, part of the effect we identify could be attributable to pre-war health rather than to military death rates per se.

To deal with this issue, we explore in Appendix G the sources of variation in enlistment rates across départements, and analyze whether they are correlated with military death rates. We find that départements with lower enlistment rates were the ones with adverse pre-war health conditions. Nevertheless, we show that controlling for rurality fully captures variations in pre-war health conditions that might affect the rate of military fatalities.

3.3.5. Adjusting Standard Errors for Spatial Correlation

As apparent on Figure 3, military death rates look spatially clustered. In section 2, we discussed how the geography of the organization of the army as well as the policies implemented by the Ministry of War to support the industrial war effort both generated this spatial distribution. Throughout the analysis, we cluster standard errors at the département level and implicitly assume that départements are independent from one another.

[36]The military records we use also contain the location of recruitment of each soldier, which corresponds to their location of residence at the time of recruitment in the army at age 20. This information could in principle be used to build a measure unaffected by unobserved patterns of migration between birth date and recruitment date. However, such a measure is contaminated with measurement error because the geography of military recruitment did not overlap with département boundaries. Appendix F.2 provides more details.

In Appendix Table A.8, we show that the results are robust to other forms of spatial correlation. First, we replicate the analysis when using larger clusters: administrative regions and military regions. There were 21 administrative regions and 22 military regions.[37] In both cases, standard errors are similar to the ones obtained when clustering at the département level. Moreover, although the degrees-of-freedom adjustment is more strict, all the results are significant at similar levels. Second, we follow Conley (2008) and adjust standard errors to account for spatial correlation, allowing for a linearly decaying correlation up to a distance cutoff around each département. We use 250, 500, and 750 kilometers cutoffs. Given the average size of French départements, the 500 kilometers cutoff corresponds approximately to allowing a correlation between each département and its twenty neighboring départements. In all cases, standard errors corrected for spatial correlations are smaller than the clustered standard errors, and significance levels are similar.

3.3.6. Population-Weighted Regressions

French départements exhibit large disparities in population levels. Throughout the analysis, we provide an equal weight to each unit. However, population-weighted estimates may be more relevant quantities for understanding the overall impact of WWI on female labor force participation. In Appendix Table A.9, we replicate the main results of the paper when using département populations as weights in the regressions. The point estimate increases from 0.35 to 0.48 with population weights. This is because population-weighted regressions give more weight to départements with larger industrial sectors, which benefited the most from the inflow of women in the labor force during the interwar period.

3.3.7. Post-War Migration Patterns

A final concern is related to post-war migration patterns of women seeking employment. Suppose that wages were higher in départements with higher military fatalities, reflecting the relative loss of male labor input. This could increase the relative wage of female labor that it is substitutable with male labor. If women were mobile, the overall effect of military fatalities on female labor force participation could partially be attributed to some women leaving low military death rate départements for high military death rate départements. Appendix Figure A.1 displays national trends in female migration patterns. The share of female population born in their département of residence was declining throughout the period, but this trend was not altered by the war, alleviating the concern that labor mobility may confound the results. Nevertheless, to address this potential concern, we run specification

[37]The composition of each military region is from Boulanger (2001, pp. 335–337).

2 with the share of the female population born in their département of residence as the dependent variable. We find no correlation with military death rates (a coefficient of 0.08, and a standard error of 0.11).

4. Mechanisms

We now investigate the mechanisms underlying the impact of military fatalities on female labor force participation in the interwar period. Both changes in the supply and demand for female labor could account for the pattern in the data. Military fatalities could have induced women to increase their supply of labor for three reasons. First, single women were facing deteriorated marriage prospects after the war due to the shortage of men, decreasing the expected value of marriage (Abramitzky et al. 2011). As a result, some women could have preferred to enter the labor market rather than to marry with a lower quality husband. Alternatively, they could have spent more time searching for a valuable husband, thereby entering the labor market for a limited period of time as secondary earners in their families.[38] Second, deteriorated marriage market conditions could have decreased the bargaining position of married women within the household, leaving them with a lower share of household income (Grossbard 2014). This negative income shock could in turn have increased their labor supply. Third, some war widows could have entered the labor force to compensate for the loss of their husbands' incomes as subsidies to war widows were relatively small.[39] For instance, the cumulated amount of subsidies to a war widow in 1921 amounted only to a quarter of the average labor income of a working woman—Appendix Figure A.2 simulates real incomes of single working women, single mothers, and war widows in the interwar period to support this point. This negative income shocks could have induced the daughters of war widows to enter the labor force as well. On the other hand, the scarcity of men could have induced firms to demand more female labor, especially in sectors where female labor was a close substitute to male labor.

In this section, we explore whether supply (section 1) or demand channels (section 2) can explain the pattern we find in the data. The empirical evidence unambiguously points towards a supply side explanation: single women entering the labor force while searching for a husband, and war widows working to compensate for the loss of their husbands' incomes.

[38]Historical accounts support the idea that the market place was a platform to meet a husband. For instance, a female factory superintendent recounts the following in a survey conducted in factories in 1934: "[...] the young [female workers] prefer working at the factory then in their homes. Young women consider [the factory] as an occasion to get married" (Delagrange 1934, p. 39).

[39]This was the case at least until the early 1930s—subsidies to war widows sharply increased in 1931 to about 75% of the labor income of an average working women.

In section 3, we also show that the rise in female labor force participation *during* the war was orthogonal to the distribution of military fatalities, and further that it cannot explain the post-war entrance of women in the labor force.

4.1. Supply Factors: The Marriage Market Channel

In this section, we assess the effect of military fatalities on female labor force participation through labor supply channels. To uncover changes in labor supply conditions, we focus on transmission mechanisms through the marriage market. Summary statistics for the share of women of each marital status before and after the war are provided in Appendix Table A.10. The share of single women sharply increased after the war, especially among women aged 20 to 29: while 39% of women of this age group were single in 1911, 44% of them were single in 1921. The share of widows also sharply increased after the war, especially among the women aged 30 to 39: while 4% of women within this age group were widows in 1911, 10% of them were widows in 1921.

4.1.1. Military Fatalities and the Post-War Marriage Market

We first document how military fatalities tightened the post-war marriage market. Using a different, more aggregated, source of data for military death rates, Abramitzky et al. (2011) show that the war worsened the position of women in the marriage market as men became more scarce. As a result, women were less likely to marry after the war in départements that had relatively more military fatalities. To analyze the impact of military fatalities on the interwar marriage market, we estimate the following specification for various age groups and marital statuses:[40]

$$\mathtt{Y}_{a,d,t} = \beta\ \mathtt{death\_rate}_d \times \mathtt{post}_t + \theta'\ \mathbf{X}_{d,t} + \gamma_d + \delta_t + \varepsilon_{a,d,t}, \tag{4}$$

where $\mathtt{Y}_{a,d,t}$ is the share of women of a particular marital status in age group a, département d, and year t. $\mathtt{post}_t$ is an indicator variable for $t > 1918$. We report the results in Table 7. The estimates are very similar to those in Abramitzky et al. (2011, p. 136), suggesting that their analysis is robust to extending the sample to the entire interwar period and to including more pre-war years.[41] Overall, we find that women in départements that had

[40] Because the marital statuses "widowed" and "divorced" are not available separately except in the censuses of 1911 and 1921, we group widowed and divorced women into the same category. Moreover, because age groups were defined differently in the census of 1906, we exclude this census from the sample. As a result, the sample consists of the following census years: 1901, 1911, 1921, 1926, 1931, and 1936.

[41] We reproduce the results presented in Abramitzky et al. (2011, Table 2, p. 136) in Appendix Table A.11 when clustering standard errors at the département level.

higher military death rates were more often single (panel A) and widowed (panel B) after the war. In particular, the estimates imply that in départements that experienced military death rates of 20% rather than 10%, the proportion of single women aged 20 to 29 was 2.7 percentage points higher after the war, compared to an average of 39% in 1911 (column 1). The effect is smaller for older women. Moreover, women aged 40 to 49 were most likely to lose their husbands during the war.[42]

Table 7
Female Marital Status

Dependent variable:	A. Single (%)			B. Widow (%)		
Age group:	20–29	30–39	40–49	20–29	30–39	40–49
	(1)	(2)	(3)	(4)	(5)	(6)
Death rate × post	0.27***	0.23***	0.14***	-0.00	0.09***	0.17***
	[0.07]	[0.05]	[0.04]	[0.01]	[0.03]	[0.03]
Rural	Yes	Yes	Yes	Yes	Yes	Yes
Born in dép.	Yes	Yes	Yes	Yes	Yes	Yes
Département FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	522	522	522	522	522	522
Départements	87	87	87	87	87	87
Within R^2	0.824	0.258	0.321	0.848	0.928	0.633
1911 mean	38.9	14.6	11.2	1.3	4.7	11.5

Notes. This table reports the OLS coefficients from estimating specification 4. The dependent variable is the share of single women in panel A, and the share of widowed women in panel B. *Widows* also includes divorced women. The census years are 1901, 1911, 1921, 1926, 1931, and 1936. *Rural* is the share of rural population in percents. *Born in dép.* is the share of the residing population born in the département in percents. Standard errors are in brackets, and are clustered at the département level.
*** Significant at the 1 percent level.

Data to explore labor supply channels through changes in marriage market conditions directly are scarce. For instance, the censuses do not provide information on female labor force

[42]Knowles and Vandenbroucke (2016) show that the flow of marriages actually increased for both men and women in the intewar period. There are two reasons for this: first, many delayed their marriage during the war, and second, the men who died during the war were the ones with a low propensity to marry, i.e., the youngest men. As a result, the pool of single men left after the war was composed by men with a high propensity to marry. This change in the composition of the pool of single men was strong enough to compensate for the scarcity of single men and generate an increase in the flow of marriages in départements that experienced more military fatalities. Nevertheless, we do not find a correlation between changes in marriage flows and changes in female labor force participation.

participation by marital status at the département level. This impedes us from testing the second labor supply channel directly (increased labor supply by married women). Instead, we rely on information relative to changes in the shares of single and widowed women. Nevertheless, the lack of data on labor force participation of married women is not problematic as national-level trends suggest that single and widowed women drove the overall increase in female labor force participation in the interwar period: while labor force participation rates of married women remained roughly constant between 1911 and 1921, those of single and widowed women increased from 67% to 70%, and from 37% to 43%, respectively (see Appendix Figure A.3).

4.1.2. The Marriage Market as a Transmission Channel

To uncover the effect of military fatalities on female labor force participation through changes in marriage market conditions, we use tools from the causal mediation framework (Imai et al. 2011). For each decennial age group (20–29, 30–39, and 40–49), we estimate the following three equations:[43]

$$\begin{cases} \texttt{single}_{d,t} &= \beta_S \, \texttt{death\_rate}_d \times \texttt{post}_t + \theta'_S \, \mathbf{X}_{d,t} + \gamma_{S,d} + \delta_{S,t} + \varepsilon_{S,d,t} \\ \texttt{widow}_{d,t} &= \beta_W \, \texttt{death\_rate}_d \times \texttt{post}_t + \theta'_W \, \mathbf{X}_{d,t} + \gamma_{W,d} + \delta_{W,t} + \varepsilon_{W,d,t} \\ \texttt{FLFP}_{d,t} &= \beta_1 \, \texttt{death\_rate}_d \times \texttt{post}_t + \beta_2 \, \texttt{single}_{d,t} + \beta_3 \, \texttt{widowed}_{d,t} + \theta' \, \mathbf{X}_{d,t} + \gamma_d + \delta_t + \varepsilon_{d,t}. \end{cases} \tag{5}$$

Data for female labor force participation by decennial age group before the war are only available for the census of 1901. While dropping two pre-war years could be problematic, this information enables to match labor and marriage market outcomes for women by age group. This is highly valuable as women at different points in their life-cycles may be differentially affected by the war. Moreover, there was little differential pre-war trends in female labor force participation, so that the main results are seldom be affected by this omission.[44]

The quantities of interest are $\widehat{\beta}_2 \times \widehat{\beta}_S$ and $\widehat{\beta}_3 \times \widehat{\beta}_W$. They represent the effect of military fatalities on female labor force participation through each channel under a modified version of the "sequential ignorability" assumption (Imai et al. 2011): there are no differential trends in labor and marriage market outcomes across départements with varying levels of military

[43] An alternative way would be to add interactions to the third equation and estimate $\texttt{FLP}_{d,t} = \beta_1 \, \texttt{death\_rate}_d \times \texttt{post}_t + \beta_2 \, \texttt{single}_{d,t} + \beta_3 \, \texttt{single}_{d,t} \times \texttt{death\_rate}_d \times \texttt{post} + \beta_4 \, \texttt{widowed}_{d,t} + \beta_5 \, \texttt{widowed}_{d,t} \times \texttt{death\_rate}_d \times \texttt{post} + \theta' \, \mathbf{X}_{d,t} + \gamma_d + \delta_t + \varepsilon_{d,t}$. However, this procedure cannot provide estimates of the size of the mediators along with confirence intervals (Imai et al. 2011, p. 784).

[44] This is indeed the case when replicating Table 6 while and dropping the years 1906 and 1911 (see Appendix Table A.12). Removing the year 1906 when replicating the marriage market results from Table 7 also generates similar estimates (see Appendix Table A.13).

death rates, and, conditionally on military death rates, there are no differential trends in labor market outcomes across départements with varying levels of marriage market outcomes. We show in Appendix H that imposing these assumptions is reasonable in this context.

Table 8 reports the estimates of the third equation of specification 5 for each decennial age group. Odd columns report the impact of WWI military fatalities on female labor force participation by age group. While all age groups were driven to enter the labor force during the interwar period, older women were twice as much affected as younger women: in départements that experienced military death rates of 20% rather than 10%, labor force participation rates of women aged 30 to 39 and 40 to 49 increased by 17% relative to their pre-war levels. In contrast, labor force participation rates of women aged 20 to 29 increased by 8% (2.7/34.7).

Even columns contain two quantities of interest: first, they show how the coefficient on military death rates ($\widehat{\beta}_1$) changes onces marriage market outcomes are included, and second, they show the effect of changes in marriage market conditions on female labor market outcomes ($\widehat{\beta}_2$ and $\widehat{\beta}_3$). These results imply that in départements that experienced a military death rate of 20% rather than 10%, labor force participation rates of women aged 30 to 39 were 1.6 percentage point higher because of the rise in singlehood (2.5×0.64), and 0.5 percentage point higher because of the rise of widowhood (0.8×0.62).[45] These two channels together explain 46% of the total effect of military fatalities on labor force participation of women aged 30 to 39 ($1 - 0.26/0.48$). Similarly, they explain 36% of the total effect on women aged 40 to 49, and 22% of the total effect on women aged 20 to 29.

Overall, these results imply that women aged 30 to 39 were most impacted by the war because they were affected through both margins: increased singlehood and increased widowhood. Younger women were mostly affected through one margin (singlehood), and older women through another margin (widowhood).

4.2. Demand Factors: The Substitution Channel

The increase in female labor force participation in the interwar period may also be explained by firms substituting male labor with female labor to cope with the scarcity of men. In a partial equilibrium framework, an increase in female wages could uncover this phenomenon. However, we documented that women increased their labor supply after the war due to changes in marriage market conditions. As a result, changes in wages can in principle only provide a partial view: on the one hand, rising female wages would imply that the increase

[45] For consistency, we use the estimates from Table A.13 instead of those in Table 7 as it does not contain the year 1906.

Table 8
The Marriage Market Channel

Dependent variable:	Female Labor Force Participation					
Age group:	A. 20–29		B. 30–39		C. 40–49	
	(1)	(2)	(3)	(4)	(5)	(6)
Death rate × post	0.27***	0.21**	0.48***	0.26***	0.47***	0.30***
	[0.09]	[0.09]	[0.10]	[0.08]	[0.10]	[0.10]
Share single		0.27***		0.64***		0.78***
		[0.07]		[0.12]		[0.14]
Share widows		1.08***		0.62***		0.41***
		[0.41]		[0.14]		[0.15]
Rural	Yes	Yes	Yes	Yes	Yes	Yes
Born in dép.	Yes	Yes	Yes	Yes	Yes	Yes
Département FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	435	435	435	435	435	435
Départements	87	87	87	87	87	87
Within R^2	0.685	0.704	0.685	0.736	0.591	0.664
1901 mean	34.7	34.7	30.1	30.1	27.7	27.7

Notes. This table reports the OLS from estimating specification 5. The dependent variable is female labor force participation by decennial age group. The census years are 1901, 1921, 1926, 1931, and 1936. *Share single* is the share of women of the relevant age group that are single. *Share widows* is the share of women of the relevant age group that are widows or divorced. *Rural* is the share of rural population in percents. *Born in dép.* is the share of the residing population born in the département in percents. Standard errors are in brackets, and are clustered at the département level.
*** Significant at the 1 percent level. ** Significant at the 5 percent level.

in the demand for female labor was strong enough to overcompensate the depressing effect of increased female labor supply on wages, and, on the other hand, declining female wages would imply that the potential increase in the demand for female labor was not large enough to compensate the depressing effect of increased female labor supply on wages.

To overcome this general equilibrium issue and assess the magnitude of the potential increase in the demand for female labor through substitution, we analyze changes in wages across occupations with different degrees of substitutability. We first consider a set of occupations in the textile manufacturing sector that were mostly occupied by women: ironer, seamstress, and milliner—in 1911, there were about 260 women per man in these occupa-

tions.[46] Hourly wage rates for these occupations are available across various cities from 1901 to 1926.[47] Focusing on these occupations enables to fix the demand curve for female labor: because male and female labor are not substitutes in these occupations, the scarcity of men is unlikely to have affected the demand for female labor differentially across departments with varying levels of military death rates.[48] As a result, only shifts in the supply curve of female labor should affect equilibrium female labor force participation rates in these occupations.

We aggregate city-level hourly wage rates for these occupations at the département level and use a differences-in-differences strategy analogous to specification 2. We report the results in panel A of Table 9. Consistent with our argument, female wages declined across all three occupations in départements that had higher military death rates. While these occupations are not representative of all female occupations, they are representative of a large share of the jobs women held in this time period, especially in the manufacturing sector. Given that the impact of the war was especially salient in that sector of activity, these results suggest that labor supply factors alone are an important explanation for the impact of WWI military fatalities on female labor force participation in the interwar period.

Next, we consider occupations in which male and female labor are close substitutes: domestic services. Two surveys from 1913 and 1921 provide wage information for female cooks and housekeepers across various cities.[49] Focusing on these occupations provides an upper bound for the potential role of changes in labor demand through substitution. Similar to the analysis above, we aggregate city-level hourly wage rates for these occupations at the département level and use a differences-in-differences strategy. We report the results in panel B of Table 9. Again, female wages declined across both occupations in départements with higher military death rates. These results suggest that increased female labor supply was the driving force behind the post-war rise in female labor force participation. Nevertheless,

[46]See *Résultats Statistiques du Recensement Général de la Population 1911*, Tome I, Part 3, p. 28.

[47]In fact, these are the only female occupations for which wage rates are available throughout this time period. Wage information for other female occupations in the manufacturing sector (laundress, lacemaker, embroiderer, and vest maker) is only available for the 1920s. Wage information at the female occupation level is not available for the 1930s.

[48]This reasoning makes two implicit assumptions. First, that income shocks due to the war do not affect labor demand differentially across départements, i.e. that while labor is not perfectly mobile across space, tradable goods are; second, that there are no complementaries between the female labor input and other input factors. More specifically, firms may have compensated for the scarcity of male labor in the manufacturing sector by investing in physical capital. If physical capital is complementary to female labor, then the scarcity of men could have indirectly affected female labor demand curves. We show in Appendix Table A.14 that although firms did increase their level of physical capital in départements that had higher military death rates, the magnitude of this mechanism is relatively small: point estimates on measures of physical capital represent 2–4% of their pre-war levels. Moreover, firms did not substitute toward foreign labor.

[49]The surveys provide yearly wage rates which we transform into hourly wage rates, assuming that women in these occupations worked 2,808 hours per year in 1913 (Bayet 1997, p. 26).

Table 9
The Substitution Channel

Dependent variable:	Log Hourly Wage Rate				
	A. Manufacturing			B. Domestic	
Occupation:	Ironer	Seamstress	Milliner	Cook	Housekeeper
	(1)	(2)	(3)	(4)	(5)
Death rate × post	-0.010***	-0.012***	-0.008**	-0.006***	-0.002*
	[0.004]	[0.003]	[0.003]	[0.002]	[0.001]
Rural	Yes	Yes	Yes	Yes	Yes
Born in dép.	Yes	Yes	Yes	Yes	Yes
Département FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	386	395	366	173	171
Départements	87	87	87	87	87
Within R^2	0.951	0.955	0.951	0.901	0.948
1911 mean (Francs)	0.21	0.23	0.25	0.20	0.16

Notes. This table reports the OLS coefficients from estimating specification 2. The dependent variable is the female log hourly wage in Francs. Survey years for columns 1–3 are 1901, 1906, 1911, 1921, and 1926. Survey years for columns 4–5 are 1913 and 1921. *Rural* is the share of rural population in percents. *Born in dép.* is the share of the residing population born in the département in percents. Standard errors are in brackets, and are clustered at the département level. See Appendix J for details about variable sources and definitions.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

increased labor demand through substitution appears to have played a limited role in the domestic services sector as the net magnitude of the negative impact of military fatalities on female wages is smaller than for occupations in the textile manufacturing sector: while in départements that experienced military death rates of 20% rather than 10%, female wage rates declined by 8–12% in the textile manufacturing sector, they declined by 2–6% in the domestic services sector. Overall, if there were some degree of substitution between male and female labor in the interwar period, it was relatively small compared to the increased labor supply of women. Instead, firms compensated for the scarcity of male labor by substituting toward physical capital, although the magnitude of this mechanism is relatively small (see Appendix Table A.14).

4.3. Female Labor During the War

We now examine whether the war affected subsequent female labor force participation through the entrance of women in the labor force *during* the war, as it has been analogously documented for the post-WWII period in the U.S. (Goldin 1991, Acemoglu et al. 2004, Goldin and Olivetti 2013). First, the women who entered the labor force during the war could have remained in the labor force after the war because they acquired valuable skills and experience, updated their beliefs about the payoffs from working, or improved their information about labor market conditions. Second, men's beliefs about women's abilities as workers could have changed as women successfully took on typically male responsibilities during the war. We show that the inflow of women in the labor force during the war was not correlated with the distribution of military fatalities, making these potential mechanisms orthogonal to the ones we highlight in this paper. Further, consistent with the historical literature, we find that the inflow of women in the labor force during the war did not trigger any change in female labor force participation after the war through these mechanisms.

4.3.1. The Inflow of Women in the Labor Force During the War

The period of the war and its direct aftermath can be divided into four phases: a phase of complete industrial disorganization between August 1914 and January 1915, a phase of progressive industrial mobilization between January 1915 and November 1918, a phase of industrial demobilization between November 1918 and November 1919, and a phase of recovery between November 1919 and October 1922. In August 1914, all belligerent nations anticipated a short war: since the middle of the nineteenth century, it was believed that a successful military strategy consisted in an extremely strong initial offensive that would destroy the opponent within a short period of time (Reboul 1925). For this reason, the French plan of military mobilization of 1912 did not mention any specifics regarding the industrial organization that was supposed to support a potentially long war. As a result, a large part of the French industrial system came close to paralysis in August 1914. We document this phenomenon in Figure 6, which displays the evolution of the number of operating firms along with male and female employment levels in the industrial sector throughout the war. To make relative changes more apparent, we standardize levels to 100 in July 1914. Compared to July 1914, 53% of all industrial firms were still operating in August 1914, and male and female employment were respectively down to 32% and 43% of their pre-war levels.

By the end of August 1914, the French army had already lost about 200,000 men, amounting to 15% of all military fatalities after four years of combats. The military command soon realized that the war would last longer than anticipated and that its industrial plan to sup-

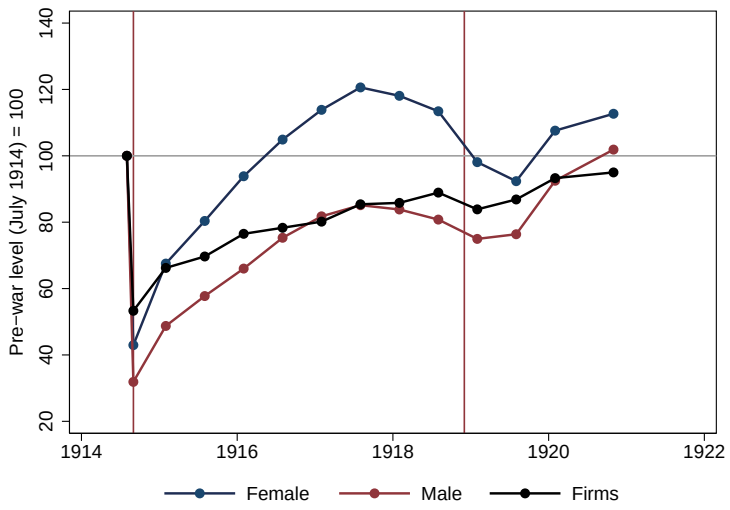


Figure 6. *Labor During World War I (August 1914–October 1920)*

Notes. *Female* indicates the number of women working in the industrial sector, *Male* indicates the number of men working in the industrial sector, and *Firms* indicates the number of operating firms in the industrial sector. We normalize pre-war levels to 100 in July 1914. See Appendix J for details about variable sources and definitions.

port the ongoing war effort was highly insufficient. For instance, while it had planned to produce 13,000 shells per day at the beginning of the war, the troops were using 150,000 shells per day in combats by January 1915 (Porte 2005, pp. 66–67). To manage the extended needs of the army, the military command centralized the industrial war effort under the State Secretariat of Artillery and Ammunitions in November 1915, and started to coordinate a vast network of public and private industrial firms.[50] Moreover, the government incentivized firms to employ alternative forms of labor such as women, immigrants, and war prisoners.[51] As a result, the number of women working in the industrial sector exceeded its pre-war level by 1916. This phenomenon was especially salient in sectors that directly supplied weapons and machineries to the army. For instance, in the metallurgic sector, the number of working women exceeded its pre-war level as early as January 1915. By July 1917, it exceeded its pre-war level by a factor 7 in this sector.[52] At the end of the war, the need for new equipments vanished. Moreover, the government issued laws to help soldiers return to their pre-war job, and even offered a monetary lump sum equivalent to a month

[50]This Secretariat was created by the Order of November 3rd, 1915. See the *Journal Officiel de la République Française, Lois et Décrets*, *47* (306), pp. 8108–8109, dated November 11th, 1915.

[51]These incentives are detailed in the *Ciruclaire* of the Ministry of War of November 10th, 1915. See the *Journal Officiel de la République Française, Lois et Décrets*, *47* (306), p. 8110, dated November 11th, 1915.

[52]Appendix Table A.15 provides a comprehensive view of the evolution of the number of working women in various industrial sectors throughout the war.

worth of pay to any woman who would quit her job in war industries.[53] As a result, female employment in the industrial sector dropped to below its pre-war level by the end of 1919. Shortly after, however, employment levels rose again, mostly because of the reconstruction effort.

To capture the intensity of inflows of women in the labor force during the war, we use the level of female employment in the industrial sector in July 1917 relative to that in July 1914 as female labor force participation was the highest in that month.[54] We show in panel A of Appendix Table A.16 that départements that experienced higher spikes in female labor during the war did not experience higher nor lower military death rates. As a result, the potential impact of female labor during the war on subsequent female labor force participation is orthogonal to the mechanisms highlighted in this paper.

It is nevertheless worth asking whether the women who entered the labor force during the war to work in war industries kept working after the war. If true, this should have resulted into a positive relationship between spikes in female labor during the war and changes in female labor before and after the war. Using a difference-in-differences strategy, we can show that départements that experienced larger increases in female labor during the war did not experience any post-war increase in female labor (see columns 1 and 2 of Appendix Table A.17). These findings are consistent with contemporaneous accounts of labor inspectors who systematically described in their reports how male managers assigned basic tasks to women by decomposing men's work into smaller, easier tasks. For instance, a report of January 1918 describes: "[t]o make female labor possible and enable them to replace men, industrialists have, in many regions, modified and improved their managing methods. They divide the labor to the extreme, organize the production in series and assign female workers to very delimited tasks" (*Bulletin du Ministère du Travail et de la Prévoyance sociale*, *25* (1), 1918, p. 11). Because of such an extreme division of labor, women could hardly acquire human capital transferable to other sectors after the war.[55]

[53]The law of November 22nd, 1918, ensured that soldiers could claim their pre-war job: "The administrations, offices, public, or private firms must guarantee to their mobilized personnel [...] the occupation that all had at the moment of its mobilization" (*Journal Officiel de la République Française, Lois et Décrets*, *50* (320), pp. 10120–10121, dated November 24th, 1918). In November 1918, the Ministry of Armament was telling female workers: "[b]y coming back to you previous occupations, you will be useful to your country as you have been by working in war industries in the past four years. [...] Each [female] worker who expresses the will to quit ones firm before December 5th, 1918, will receive the amount of thirty days of salary as a severance pay" (*Bulletin du Ministère du Travail*, 1919, pp. 45*–46*).

[54]Our results are robust to using alternative dates to measure the spike in female labor during the war.

[55]Historians have further pointed out that instead of an inflow of women in the labor force, the women working in war factories were already working before the war. For instance, Downs (1995, p. 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

4.3.2. Changes in Men's Beliefs about Gender Roles

The war could also have increased female labor in the post-war period by changing men's beliefs about gender roles, and thereby their demand for female labor. For instance, men may have updated their beliefs about women's abilities because of their positive role during the war in industries and in farming. To measure how men's beliefs about gender roles changed before and after the war, we use *députés'* support to the extension of the suffrage to women at the Assemblée Nationale.[56] We build on the fact that the extension of the suffrage to women was discussed before and after the war. Women did not have the right to vote prior to the war. However, this matter was the subject of much debates. In fact, a proposal to extend the suffrage to women—the Dussaussoy-Buisson bill—was supposed to be voted on in 1915, but the war interrupted the legislative process. This bill was eventually voted on in May 1919, and adopted by 324 votes against 87 (it was later rejected by the Sénat, France's upper house). This phenomenon is not specific to France: Hicks (2013) finds that wars in the twentieth century doubled the likelihood of a belligerent country to grant women with the right to vote within one year following the conflict.

We collected data on the public support of députés to the extension of the suffrage to women before the war from an open letter written by several women's rights organizations addressed to the Assemblée Nationale. This letter was published in June 1914.[57] The data for the votes on the extension of female suffrage in May 1919 are from the reports of the debates in the Assemblée Nationale.[58] We then constructed an average support for female suffrage at the département level before and after the war by aggregating supports and vote choices of députés from each département. Appendix Table A.18 reports these measures together with the data at the député level. While 32% of députés supported female suffrage in 1914, 79% did so in 1919.

This measure may not adequately capture men's beliefs about gender roles. First, the views of a département's députés may not represent the views of the département's general population. Moreover, it may capture only a subset of men's beliefs about gender roles, such as women's political abilities. To alleviate this concern, we build a measure of religious conservatism before the war at the département level. Presumably, religious conservatism and beliefs about gender roles should be correlated. For instance, Przeworski (2009) finds that countries that are more Catholic adopted female suffrage later in the course of their

limelight of weapons production", cited in Vandenbroucke (2014, p. 118).

[56]The Assemblée Nationale is France's lower house. Members of the Assemblée Nationale are the *députés*.

[57]A copy of this letter is available in Appendix K.

[58]See the *Journal Officiel de la République Française, Débats Parlementaires*, 11e Législature, Session ordinaire de 1919, pp. 2365–2366, dated May 20th, 1919.

history. To measure religious conservatism at the local level, we use députés' votes on the *Loi de 1905*, which separated the Church from the State in 1905. This law is particularly relevant for our purpose because it was one of the most disputed laws in France's political history. We collected the data on the votes of each député from the reports of the debates in the Assemblée Nationale.[59] We show in Appendix Table A.19 the correlation between the votes for the *Loi de 1905* and the support to the extensions of the suffrage to women in June 1914, and the votes in May 1919. Départements in which députés supported the separation of the Church from the State in 1905 also supported the extension of female suffrage before the war more often. No such relationship exists after the war, suggesting that local attitudes changed after the conflict. These findings suggest that the support to the extension of the suffrage to women is a reasonable measure for local conservatism toward gender roles.

A difference-in-differences strategy reveals that changes in the support to the extension of the suffrage to women are uncorrelated with the distribution of military death rates: départements in which députés switched their support for female suffrage did not experience different military death rates (panel B in Appendix Table A.16). Moreover, these changes are uncorrelated with changes in female labor force participation before and after the war (columns 3 and 4 of panel A in Appendix Table A.17).

5. Conclusion

In this paper, we show that the shortage of men induced by World War I increased female labor force participation in the interwar period. In particular, départements with military death rates of 20% rather than 10% experienced an increase in female labor force participation of about 12% compared to pre-war levels. This effect is stable throughout the interwar period, and robust to alternative empirical strategies. Our analysis reveals that labor supply factors (changes in marriage market conditions) rather than labor demand factors (substitution from male to female labor) generated the pattern observed in the data. Further, consistent with the historical literature, we find that the inflow of women into the labor force during the war was only temporary.

Our results help understand the consequences of sex ratio imbalances for labor markets beyond the context of World War I. While most studies focus on the scarcity of women and its implications, this paper reveals that the scarcity of men produces symmetric effects. We further show that theory-founded mechanisms played a substantial role in the aftermath of this significant event of history. Yet, the response of female labor to sex ratio imbalances

[59] *Journal Officiel de la République Française, Débats Parlementaires*, 8e Législature, Session ordinaire de 1905, pp. 2701–2707, dated July 3rd, 1905.

presented in this paper is arguably amplified by this context: France's revolution of female labor was yet to come, and its economy was still in the midst of the structural transformation. As a result, changes in marriage market conditions affected the extensive margin of female labor to its full potentialities. Nevertheless, the qualitative aspects we identify remain equally valid today, and help understand the labor market implications of wars, sex-selective abortion, and mass migrations that alter gender balances throughout the world.

References

Abramitzky, Ran, Adeline Delavande, and Luis Vasconcelos, "Marrying Up: The Role of Sex Ratio in Assortative Matching," *American Economic Journal: Applied Economics*, 2011, *3* (3), 124–157.

Acemoglu, Daron, David H. Autor, and David Lyle, "Women, War, and Wages: The Effect of Female Labor Supply on the Wage Structure at Midcentury," *Journal of Political Economy*, 2004, *112* (3), 497–551.

Almond, Douglas, Lena Edlund, and Kevin Milligan, "Son Preference and the Persistence of Culture: Evidence from South and East Asian Immigrants to Canada," *The Population and Development Review*, 2013, *39* (1), 75–95.

Amuedo-Dorantes, Catalina and Shoshana Grossbard, "Cohort-Level Sex Ratio Effects on Women's Labor Force Participation," *Review of Economics of the Household*, 2007, *5* (3), 249–278.

Angrist, Josh, "How Do Sex Ratios Affect Marriage and Labor Markets? Evidence from America's Second Generation," *Quarterly Journal of Economics*, 2002, *117* (3), 997–1038.

Aronow, Peter M. and Cyrus Samii, "Does Regression Produce Representative Estimates of Causal Effects?," *American Journal of Political Science*, 2016, *60* (1), 250–267.

Battagliola, Françoise, *Histoire du Travail des Femmes*, La découverte, 2010.

Bayet, Alain, "Deux Siècles d'Évolution des Salaires en France," 1997.

Bellou, Andriana and Emanuela Cardia, "Occupations After WWII: The Legacy of Rosie the Riveter," *Explorations in Economic History*, 2016, *62*.

Bonhomme, Stéphane and Elena Manresa, "Grouped Patterns of Heterogeneity in Panel Data," *Econometrica*, 2015, *83* (3), 1147–1184.

Boulanger, Philippe, *La France Devant la Conscription: Géographie Historique d'une Institution Républicaine, 1914-1922*, Economica, 2001.

Carranza, Eliana, "Soil Endowments, Female Labor Force Participation, and the Demographic Deficit of Women in India," *American Economic Journal: Applied Economics*,

2014, *6* (4), 197–225.

Charles, Kerwin Kofi and Ming Ching Luoh, "Male Incarceration, the Marriage Market, and Female Outcomes," *The Review of Economics and Statistics*, 2010, *92* (3), 614–627.

Chiappori, Pierre-Andre, "Collective Labor Supply and Welfare," *Journal of political Economy*, 1992, *100* (3), 437–467.

Coale, Ansley J., "Excess Female Mortality and the Balance of the Sexes in the Population: An Estimate of the Number of 'Missing Females'," *The Population and Development Review*, 1991, *17* (3), 517–523.

Conley, Timothy, "Spatial Econometrics," in Steven N. Durlauf and Lawrence E. Blume, eds., *The New Palgrave Dictionary of Economics*, Basingstoke: Palgrave Macmillan, 2008.

Delagrange, Juliette, "Le Travail de la Femme Mariée," in Association des Surintendantes d'Usines et de Services Sociaux, ed., *Bulletin du Comité Permanent des Associations des Surintendantes d'Usines et de Services Sociaux*, 1934, pp. 31–48.

Downs, Laura Lee, *Manufacturing Inequality: Gender Division in the French and British Metalworking Industries, 1914-1939*, Cornell University Press, 1995.

Fernández, Raquel, Alessandra Fogli, and Claudia Olivetti, "Mothers and Sons: Preference Formation and Female Labor Force Dynamics," *The Quarterly Journal of Economics*, 2004, *119* (4), 1249–1299.

Gay, Victor, "The Legacy of the Missing Men: The Long-Run Impact of World War I on Female Labor Force Participation," 2017.

Goldin, Claudia, "The Role of World War II in the Rise of Women's Employment," *The American Economic Review*, 1991, *81* (4), 741–756.

___ **and Claudia Olivetti**, "Shocking Labor Supply: A Reassessment of the Role of World War II on Women's Labor Supply," *The American Economic Review*, 2013, *103* (3), 257–262.

Gonzalez-Feliu, Jesus and Antoine Parent, "Clio-Combinatorics: A Novel Framework to Analyze Military Logistics Choices Using Operations Research Techniques," in Alberto Ochoa-Zazzatti, Jons Sánchez, Miguel Cedillo-Campos, and Margain de Lourdes, eds., *Handbook of Research on Military, Aeronautical, and Maritime Logistics and Operations*, IGI Global, 2016, pp. 79–101.

Grosjean, Pauline and Rose Khattar, "It's Raining Men! Hallelujah?," Technical Report 2016.

Grossbard, Shoshana, *The Marriage Motive: A Price Theory of Marriage: How Marriage Markets Affect Employment, Consumption, and Savings*, Springer, 2014.

Guillot, Olivier and Antoine Parent, "A Microeconometric Analysis of Deaths of French Soldiers During the Great War," 2015.

Hénaff, Joseph-Hippolyte-Félix Le, "La Préparation et l'Éxécution d'un Plan de Transport de Concentration (Août-Octobre 1914)," *Revue Militaire Française*, 1922, *10* (4), 62–86.

Hicks, Daniel L., "War and the Political Zeitgeist: Evidence from the History of Female Suffrage," *European Journal of Political Economy*, 2013, *31*, 60–81.

Huber, Michel, *La Population de la France Pendant la Guerre* 1931.

Imai, Kosuke, Luke Keele, Dustin Tingley, and Teppei Yamamoto, "Unpacking the Black Box of Causality: Learning About Causal Mechanisms from Experimental and Observational studies," *American Political Science Review*, 2011, *105* (4), 765–789.

Joffre, Joseph, *Mémoires du Maréchal Joffre* 1932.

Klasen, Stephan and Claudia Wink, "'Missing Women': Revisiting the Debate," *Feminist Economics*, 2003, *9* (2-3), 263–299.

Knowles, John and Guillaume Vandenbroucke, "Fertility Shocks and Equilibrium Marriage-Rate Dynamics," Technical Report 2016.

Maruani, Margaret and Monique Meron, *Un Siècle de Travail des Femmes en France*, La Découverte, 2012.

Michel, Edmond, *Les Dommages de Guerre de la France et leur Réparation* 1932.

Porte, Rémy, *La Mobilisation Industrielle: 'Premier Front' de la Grande Guerre?*, 14-18 Éditions, 2005.

___ , "Mobilisation Industrielle et Guerre Totale: 1916, Année Charnière," *Revue Historique des Armées*, 2006, *242*, 26–35.

Prost, Antoine, "Compter les Vivants et les Morts: l'Évaluation des Pertes Françaises de 1914-1918," *Le Mouvement Social*, 2008, *222* (1), 41–60.

Przeworski, Adam, "Conquered or Granted? A History of Suffrage Extensions," *British Journal of Political Science*, 2009, *39* (2), 291–321.

Qian, Nancy, "Missing Women and the Price of Tea in China: The Effect of Sex-Specific Earnings on Sex Imbalance," *The Quarterly Journal of Economics*, 2008, *123* (3), 1251–1285.

Reboul, Frédéric, *Mobilisation Industrielle: Des Fabrications de Guerre en France de 1914 à 1918*, Berger-Levrault, 1925.

Remarque, Erich Maria, *Im Westen Nichts Neues* 1929.

Ridel, Charles, *Les Embusqués*, Armand Colin, 2007.

Schweitzer, Sylvie, *Les Femmes Ont Toujours Travaillé: Une Histoire de Leurs Métiers, XIXe et XXe siècle*, Odile Jacob, 2002.

Thébaud, Françoise, *Les Femmes au Temps de la Guerre de 14*, Payot & Rivages, 2013.

Tugault, Yves, "La Mobilité Géographique en France Depuis un Siècle: Une Étude par Générations," *Population*, 1970, *25* (5), 1019–1037.

Vandenbroucke, Guillaume, "Fertility and Wars: the Case of World War I in France," *American Economic Journal: Macroeconomics*, 2014, *6* (2), 108–136.

White, Paul, "Internal Migration in the Nineteenth and Twentieth Centuries," in Philip Ogden and Paul White, eds., *Migrants in Modern France*, Routledge, 1989, chapter 2, p. 21–35.

Zancarini-Fournel, Michelle, *Histoire des Femmes en France: XIXe-XXe siècles*, Presses Universitaires de Rennes, 2005.