THE MISSING MEN WORLD WAR I AND FEMALE LABOR PARTICIPATION*

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May 2017

Abstract

We explore the effect of a sharp distortion in sex ratio on female labor participation by studying the impact of military fatalities from World War I in France. We build a unique dataset containing individual level information for all 1.3 million fallen soldiers, and find that the tightness of the marriage market along with negative income shocks generated by the scarcity of men induced many young single women and older widows to enter the labor force permanently after the war. These findings are robust to alternative empirical strategies, including an instrumental variables strategy based on idiosyncrasies generated by the recruitment process of the army. (*JEL* J12, J16, J22, N34)

*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.

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"The major fact will be the breakdown of the equilibrium between the sexes. There will not be enough suitors for all young women in search of 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.

I. Introduction

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 example, 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 outcomes in both the short-run and the long-run (Abramitzky et al. 2011, Angrist 2002, 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: typically, gender imbalances are 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.

We overcome these identification issues by interpreting WWI 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 a total of 10 million men aged 15 to 50 before the war, 8 million were drafted in the army. About 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 participation in the interwar period. Our empirical strategy exploits differential changes in female labor participation before and after WWI across *départements* with varying levels of military death rates.[3] We find that

[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 (see, e.g., Coale 1991, Klasen and Wink 2003).

[2]The adult sex ratio is usually around 100 men for every 100 women because of a higher natural mortality of boys compared to girls (see, e.g., Klasen and Wink 2003).

[3]French départements are one of the three levels of government below the national level. There were 87

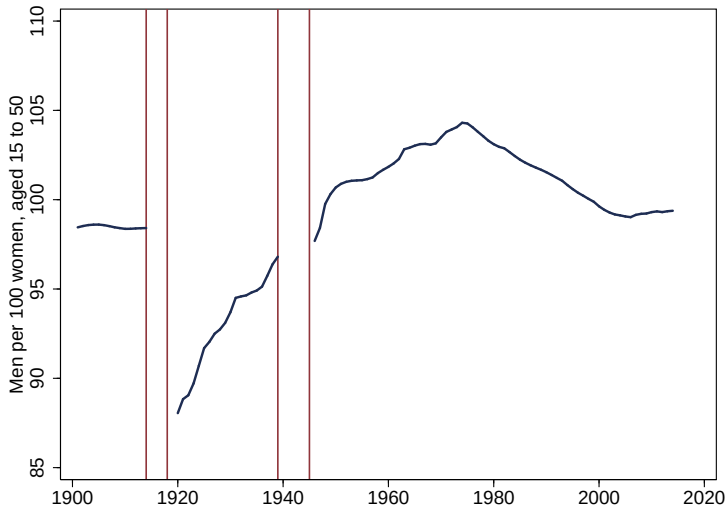
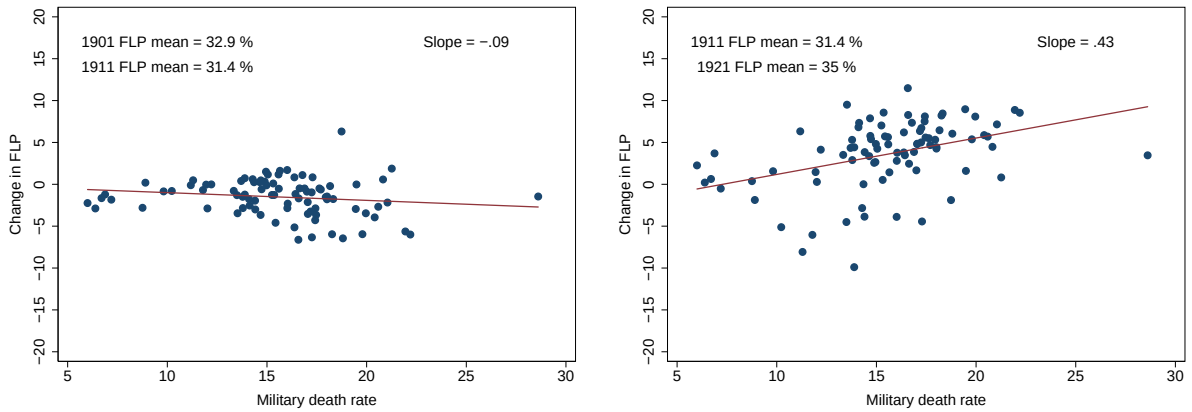


Figure 1. Adult Sex Ratio (1900-2014)

Figure 1 notes: This figure presents the adult sex ratio for the age group 15 to 50. Yearly data between 1900 and 2014. The first vertical rays (1914-1918) indicate WWI. The second vertical rays (1939-1945) indicate WWII. See appendix M for details about variable sources and definitions.

military fatalities shifted female labor 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 participation across all départements. While there is no relationship between military fatalities and pre-war changes in female labor participation between 1901 and 1911 (figure 2, panel (a)), each additional percentage point of military death rate is associated with an increase of about half a percentage point in female labor participation between 1911 and 1921 (figure 2, panel (b)). The baseline difference-in-differences estimates confirm this relationship: in départements that experienced a military death rate of 20% rather than 10%—equivalent to switching from the 25th to the 75th percentile of the distribution—female labor participation was about 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 participation of about 12% compared to pre-war levels. At the mean of the data, this implies that losing 10 men during

départements before the war, and 90 after the war. The three new départements belonged to Germany before the war. The interwar period is the period between the end of WWI and the beginning of WWII. This paper focuses on changes of female labor participation in the interwar period for the following reasons. First, it was not until after WWII that the 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 participation changed after WWII, so that the results may not be comparable across time.



(a) Changes in FLP Between 1901 and 1911 (b) Changes in FLP Between 1911 and 1921

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

Figure 2 notes: This figure presents changes in female labor participation rates across all 87 départements. *FLP* is female labor participation rate in percents. The changes are in percentage points. Each dot represents a département.

the war induced 2 women to enter the labor force. This increase in female labor participation was mostly due to women entering the domestic services and the industrial sectors.

Subsequently, we explore the validity of the identifying assumption that counterfactual trends in female labor 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—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 *Ministère de la Guerre* (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 participation. Nonetheless, to increase the credibility of the identification strategy, we relax the parallel trend assumption in four ways. First, we control for département-specific time trends in female labor participation. Second, using Bonhomme and Manresa's (2015) grouped fixed effects, 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. Finally, we run the analysis separately on groups with similar pre-war observable characteristics. All empirical strategies lead to comparable results, which are in line with the baseline estimates.

We show that our results are robust to spatial correlation across départements, to alter-

native measurements of female labor participation and military death rates, to differential pre-war health conditions and enlistment rates, and to pre-war and post-war migration patterns. Moreover, we collected historical data on war destructions and the post-war reconstruction from Michel (1932), and show that the départements in which war combats occurred do not display heterogeneous responses.

Compared to the well-documented effect of WWII mobilization on female labor participation in the U.S. (Goldin 1991, Acemoglu et al. 2004, Goldin and Olivetti 2013, Jaworski 2014, Cook-Stuntz 2015, Bellou and Cardia 2016), the effect we identify is driven by a different mechanism, and is larger in magnitude.[4] The increase in female labor participation in the U.S. after WWII was driven by women who entered the labor force *during* the war and continued working afterwards. On the contrary, we find that the increase in female labor in France was driven by women who entered the labor force *after* the war. Furthermore, our analysis of marital status data along with labor participation data in a causal mediation framework suggests that labor supply factors related to marriage market conditions are in large responsible in large part for this increase in female labor participation. On the one hand, many young single women had to enter the labor force while searching longer for a husband because of the tightness of the post-war marriage market. On the other hand, many older war widows had to enter the labor force to compensate for the loss of their husbands' incomes. Using annual labor participation data from 1914 to 1921, we find no evidence that women who entered the labor force during the war continued working after the war: consistent with contemporaneous observations by labor inspectors, firms only assigned elementary tasks to women during the war, limiting their opportunities to acquire transferable skills. Moreover, the government set up incentives for women to surrender the job they held during the war to returning soldiers.

Changes in the demand for female labor could also account for the pattern we find in the data. We analyze the evolution of real wages of men and women before and after the war, and find that female wages slightly decreased in départements that suffered relatively more military fatalities. This suggests that if there was an increase in female labor demand in départements that experienced a higher male scarcity after the war, this increase did not compensate the depressing effect of rising female labor supply on wages. Instead, we find that firms increased their stock of physical capital to compensate for the scarcity of male labor. We also explore the possibility that the war changed men's beliefs about gender roles, inducing an increase in the demand for female labor. Using changes in the support to

[4] Acemoglu et al. (2004, table 8, column 2) 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]" (p. 528).

the extension of the suffrage to women in the *Assemblé Nationale* (the French lower house) between 1914 and 1919 as a proxy for changes in beliefs about gender roles, we find no evidence for this mechanism.

The reminder of the paper is organized in the following way. The next section discusses the literature related to our research. Section III describes the data and historical context, section IV presents the main results, and section V explores the mechanisms behind our findings.

II. Related Literature

A broad literature has analyzed the impact of war mobilization and of military fatalities on female labor participation. It has mostly focused on the impact of WWII mobilization in the U.S.[5] In general, this literature finds that war mobilization during WWII increased female labor supply in the 1950s and 1960s (Goldin 1991, Acemoglu et al. 2004, Goldin and Olivetti 2013). Exploring the heterogeneity in the impact of WWII, Goldin and Olivetti (2013) find that the effect was primarily driven by higher-educated white married women who were young during the war (25 to 34 years old in 1950).[6]. WWII mobilization also affected the type of occupations held by women after the war, with a shift toward blue collar occupations and away from white collar occupations (Bellou and Cardia 2016). Relative to this literature, we contribute to the understanding of the effect of war on subsequent female labor in several ways. Besides shedding light on an alternative mechanism, the extent of military fatalities from WWI enables us to focus on the impact of a permanent rather than a temporary shortage of men. While the effect of the war is similar to the U.S. case in that female labor participation increases, it is much more persistent. For instance, we see no decline in the effect of the missing men on female labor participation throughout the entire interwar period. As a comparison, the impact of WWII mobilization on female labor in the U.S. faded out in the 1950s and 1960s. 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 (Bellou and Cardia 2016), WWI in France induced women to enter the labor force because of the disruptions to the marriage market generated by the missing men.

We also contribute to the literature exploring the effect of sex ratio imbalances on female

[5]On the bias of empirical economic history toward the case of the US, see Abramitzky (2015, Figure 3). To our knowledge, the only two papers analyzing another case are Kreibaum and Klasen (2015), which studies the impact of war-related fatalities from the Vietnam war on female labor participation, and Eder (2016), which studies the impact of war-related fatalities from WWII in Austria on structural change of the economy.

[6]See also (Jaworski 2014) for an analysis of the impact of WWII mobilization in the U.S. on female education.

labor market outcomes. The proportion of men to women diverges from its natural balance in many instances. The term "missing women" was coined by Amartya Sen (1992, 2003) who estimated that 100 million women were missing in Asia and North Africa. Such a magnitude has been confirmed by alternative demographic models (Coale 1991, Klasen 1994, Klasen and Wink 2003). The causes and consequences of this phenomenon have been subject to intense scrutiny in economics (see, e.g., Oster 2005). For example, Qian (2008) shows that, because of the comparative advantage of women in picking tea in rural China, the increase in the value of tea in the early 1980s generated a rise in female income. This, in turn, increased survival rates of girls, and balanced the sex ratio in favor of women. Other research focuses on the effect of sex-specific migration patterns. For instance, Angrist (2002) studies the consequences of changes in immigrant sex ratios in the U.S. between 1910 and 1940 on the marital and labor behavior of second-generation immigrants. He argues that these changes were mostly driven by exogenous changes in U.S. immigration laws. He finds that higher sex ratios (a relative shortage of women) induced women to marry more often, and decreased their labor participation. In the context of a developing country, Conover et al. (2015) analyze the contemporaneous effects of the scarcity of men in Mexico due to large-scale labor migrations to the U.S. Using variations in migration across Mexican states and cohorts, Conover et al. (2015) find that a reduction in sex ratios increased female labor participation, especially in high skilled jobs. Compared to this literature, the source of variation in sex ratio we use allows us to improve upon identification because it is sharper—military fatalities are concentrated within a period of about 4 years—larger in magnitude, and exogenous to the outcome under scrutiny.

More generally, we contribute to the literature studying the impact of WWI on female labor. Our unique dataset of military fatalities enables us to challenge both the popular view that the war "liberated women", and the commonly held academic view that the war was a mere "parenthesis" for female labor, by showing that it induced many women to enter the labor force permanently.[7] Moreover, we improve upon Abramitzky et al. (2011), who study the short-run effects of military fatalities on the post-war marriage market in France.[8]

[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 women in the French labor market 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]Appendix L gives more precision on the added value of our data compared to previously available measures,

III. Data and Historical Context

A. Female Labor Participation (1901-1936)

We collected female labor participation data at the département level before and after the war by transcribing tables 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. However, the census of 1901 is not fully comparable to later censuses: while wives of farmers were supposed to be systematically recorded as "in the labor force", the French statistical office recognized that not all local census agents followed this directive (Daric 1947, pp. 13-14). For this reason, we focus on female labor *net of the wives of farmers* throughout the analysis. Wives of farmers were systematically classified as *chefs d'établissement* in farming whenever they were recorded.[10] By subtracting them, we avoid this potential measurement concern as almost all female chefs d'établissement in farming were farmers' wives.[11] Moreover, this transformation allows us to focus on formal employment. We show in appendix D that all the results in the paper are unchanged when we include female chefs d'établissement in farming in the analysis.

We define labor force participation as the employed share of the population aged 15 or older—the data for labor participation disaggregated by age, or marital status, is not available at the département level for this period. Table 1 provides the average female labor participation rates across all 87 départements between 1901 and 1936. While many women entered the labor force after the war, they appear to have withdrawn from the labor market a few years later. In fact, because of the economic crisis in the 1930s, pre-war levels in female labor participation were not even recovered at the onset of WWII (Maruani and Meron 2012, pp. 39-40).[12] Consistent with this picture, historians and economists alike have described the surge in female labor just after the war as a mere "parenthesis" in the progress of female labor in France—see footnote 7 on page 7. Table 1 further motivates our decision to focus on female labor participation net of female chefs d'établissement in farming: while

such as those in Abramitzky et al. (2011) and in Vandenbroucke (2014).

[9] The census years available are: 1901, 1906, 1911, 1921, 1926, 1931, and 1936. See appendix M for more details on the sources and definitions of the variables used in the analysis. All the data used in this paper were transcribed from original paper sources.

[10] *Chefs d'établissement* can be roughly translated by "boss".

[11] Analogous procedures have been used by historians of female labor during this time period (see, e.g., Daric 1947, Maruani and Meron 2012).

[12] Appendix table A.2 provides summary statistics for various labor outcomes for each census year separately, including the share of the population of each gender working in each sector. It shows that trends in female labor participation mirrored trends in male labor participation, suggesting that labor market conditions for both genders were driven by common national trends.

the corrected measure remains stable around 33% between 1901 and 1906, the uncorrected measure displays an increase of 6 percentage points between these two censuses. Given that there was no major shock to the labor market between 1901 and 1906, this change can be attributed to the described measurement error. After 1906, the two measures have a constant difference of about 20 percentage point, suggesting that the corrected measure does not introduce any significant bias.

Table 1.
Means in Female Labor Participation Rates

	1901	1906	1911	1921	1926	1931	1936
FLP (net of farmers' wives)	32.9	32.7	31.4	35.0	29.9	30.1	28.1
FLP (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

Table 1 notes: This table presents the means in female labor participation rates across 87 départements. *FLP* stands for female labor participation rates in percents. *corrected* denotes female labor participation net of female cehfs d'établissement in farming. *Difference* is in percentage points. See appendix M for details about variable sources and definitions.

B. Measuring Military Death Rates at the Département Level

We assembled a novel dataset to build a precise measure of military death rates at the département level. To that end, we collected individual-level data from the *Mémoire des Hommes* (MDH) archive maintained by the French Ministry of Defense.[13] This archive contains the scans of individual military records for all 1.3 million French soldiers who died during the war.[14] For each of these 1.3 million deceased soldier, we record first name, last name, date of birth, and place of birth.

This dataset allows us to build a measure of military death rates at the département level. We define the military death rate in a département as as the ratio of the number of deceased soldiers born in the département to the size of the drafted population in that

[13]The original archive is accessible at `http://www.memoiredeshommes.sga.defense.gouv.fr`. See appendix L for more details on this database.

[14]The exact number of soldiers who ultimately died as a consequence of the war is not known with certainty as some soldiers died a few years after the war because of injuries or illnesses contracted during the conflict. However, the figure of 1.3 million is the consensus among historians. Prost (2008) provides a detailed account of the assessment of military fatalities. It is similarly difficult to assess the number of civilian victims during the conflict. When we add up the number of pension requests resulting from civilian fatalities, the number of victims during the bombing of cities near the front—Dunkerque, Calais, Béthunes, Arras, Lens, Reims, Pont-à-Mousson, and Nancy—and Paris, as well as the civilian victims of the commercial fleet, they amount to about 40,000 (Huber 1931, pp. 310-314)

département. We approximate the size of the drafted population by the male population aged 15 to 44 that was living 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.[15] 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 all 87 départements. The data are missing for the three départements that belonged to Germany in 1911.[16] The shaded départements in the North-East of France experienced war destructions as combats occurred on their soil. 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. 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 a low level of military death rate (10%) and départements that experienced a high level 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).[17]

Our empirical results are unaffected by various measurement inaccuracies. First, we determine the number of military fatalities in a département by using soldiers' départements of birth. This measurement is imperfect 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—according to the 1911 census, about 19% of men aged 15 to 44 were residing outside of their département of birth in 1911. Ideally, we would assign a deceased soldier to the département in which he was recruited because it is most likely his département of residence. Unfortunately, this information is not available for most soldiers. Nevertheless, Guillot and Parent (2015, p. 6) collected the full military records of a sample of about 18,000 deceased soldiers, and found that about 18% of them were recruited outside their département of birth. This could be problematic if internal migration flows were correlated with trends in female labor participation. In appendix F, we explore in detail the

[15] See the *Journal Officiel de la République Française, Lois et Décrets, 35* (81), pp. 1869-1890, dated March 23rd, 1905. Appendix table A.1 provides details about the length of military service for each successive military law until WWI.

[16] These départements are Bas-Rhin, Haut-Rhin, and Moselle. We exclude these départements throughout the analysis.

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

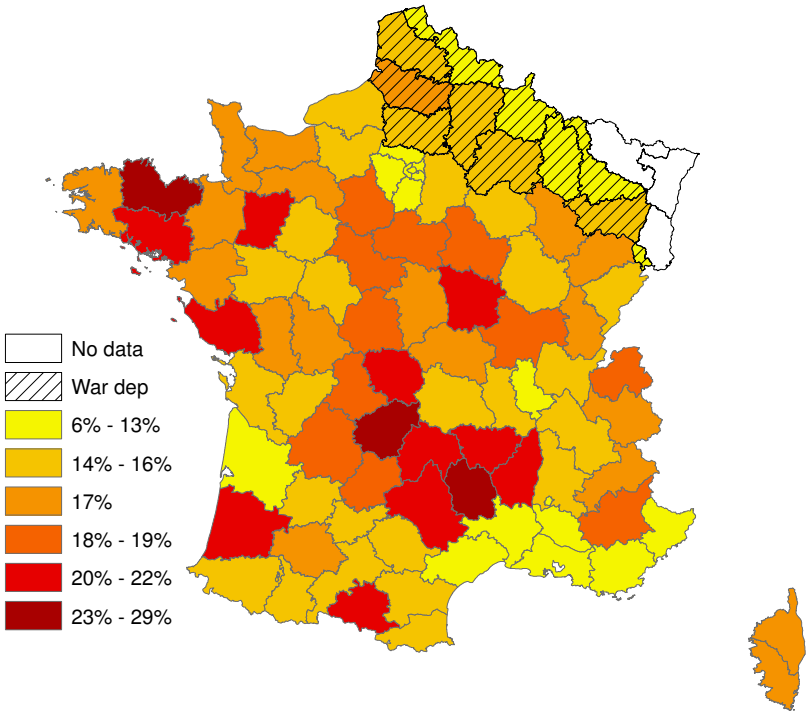


Figure 3. Distribution of Military Death Rates Across 87 Départements

robustness of our results to migration flows by using information on bilateral movements of the male population between départements in 1911. This information allows us to build a measure of military death rate that takes into account pre-war migration flows of men. Reassuringly, the results obtained using this corrected measure are similar in magnitude and precision to the ones obtained using our standard measure. A second potential concern regards the measure for the pool of drafted men. We implicitly assume that all men subject to the conscription during the war were actually recruited by the army, or, equivalently, that the recruitment rate was equal across départements. This need not be the case as some men were exempted from the conscription due to poor health conditions: indeed, only 78.5% of all men subject to the conscription were recruited by the army at the onset of the war (Huber 1931, p. 93). However, the enlistment rate increased as the 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). Using military recruitment data by cohort together with various health measures, we show in appendix G that the potential concern of differential pre-war health conditions across départements does not affect our results. Another potential concern may be that some men aged under 20 or over 48 had the opportunity to voluntarily enlist in the army. These were relatively rare cases. For instance,

while about 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).

To illustrate how much military death rates impacted adult sex ratios, we estimate the following first-difference regressions:

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

$\Delta \texttt{sex\_ratio}_{a,d}$ denotes the change in sex ratio between 1911 and 1921 for age group a in département d, and $\texttt{death\_rate}_d$ denotes the military death rate in département d. Table 2 reports the results. Because drafted men were between 20 and 48 during the war, we expect the age groups between 25 and 49 in 1921 to experience the strongest decrease in sex ratio. This is indeed what we find: for instance, a 10 percentage point increase in military death rate was associated with a decrease of almost 7 percentage points of the sex ratio for the age group 30 to 34 in 1921. As a result, the sex ratio among this age group dropped on average from 100 in 1911 to 82 in 1921.

Table 2.
OLS Estimates of Changes in Sex Ratios on Military Death Rates (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

Table 2 notes: This table reports the OLS coefficients from estimating specification 1. The dependent variable is the change in the sex ratio between 1911 and 1921 for a given age group. Sex ratios are defined as the ratio of the male population to the female population in percents. Robust standard errors are in brackets. See appendix M 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.

C. 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 various demographic and economic characteristics. Overall, more rural départements suffered relatively

more military fatalities. This correlation was for the most part generated by the policies implemented by the Ministère de la Guerre (Ministry of War) to draw industrial workers from the battlefield into war factories in order to sustain the industrial war effort. Nevertheless, we show that the distribution of military death rates was not correlated with pre-war trends in female labor participation, giving us confidence in the validity on the identifying assumption of the difference-in-differences strategy.

Geography of the Organization of the Army in 1914. 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.[18] 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 a 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.[19] 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. Thereby, troops from different military regions were increasingly mixed together starting January 1915.[20]

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 relatively different 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 belonging to the same military region could have had similar death rates for

[18]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.

[19]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.

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

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 death rates across départements of to the same military region is small (0.12), mostly because soldiers from different military regions were mixed into the same military units soon after the beginning of the war.[21]

Demographic and Economic Factors. We now explore how various départements' economic and demographic characteristics before the war help explain variations in military death rates across départements.[22] First, we divide départements into three groups of 29 départements with low, medium, and high levels of military death rates. Then, we regress various pre-war characteristics on group membership indicators—the low group is the excluded category.[23] We report the results in Table 3. Column 1 reports the means of pre-war characteristics across all 87 départements. Columns 2 and 3 report the 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.*[24,25] Finally, départements that suffered higher military death rates had lower female labor participation before the war. All these differences in levels across départements will not affect identification because they will be absorbed by the département fixed effects in the estimation.

To explore this pattern in more details, we regress military death rates on various pre-war characteristics. Some selected estimates are reported in table 4. The full set of estimates is shown in appendix table A.3. As expected, départements that suffered more military

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

[22] See appendix M for all the variable sources and definitions.

[23]More precisely, 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 $\mathbf{X}$ département d in 1911, $\texttt{medium}_d$ is an indicator for département d being in the medium group of military death rate, and $\texttt{high}_d$ an indicator for département d being in the high group of military death rate. The low death rate group is the excluded category.

[24]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.*

[25]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, 1973) and Ogden and White (2002, chapter 2) for more details on internal migrations in France in the early twentieth century.

Table 3.
Pre-War Département 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]
FLP (%)	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]

Figure 3 notes: Column 1 reports mean values for 87 départements. Standard deviations are reported 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 ($\widehat{\beta}_h$) death rate département, following the specification in footnote 23. Column 4 shows the difference between estimates in columns 3 and 2. Robust standard errors are in brackets. Each group contains 29 départements. See appendix M 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.

fatalities had lower female labor participation before the war (table 4, column 1). Moreover, more rural départements suffered more military fatalities (columns 2 and 3). The share of rural population and the share of the residing population born in the département explain most of the variation in military death rates across départements, as each explains over 60% its variance. When including all variables, only these two characteristics show statistical significance (column 4). Finally, the corresponding coefficients barely change, either when including (column 5) or excluding (column 6) female labor 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 born in the département explain about 75% 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)
FLP	-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

Figure 4 notes: This table reports the OLS estimates from regressing military death rates on pre-war characteristics. *FLP* is the female labor 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. *Demographic*, *Economic*, and *Other* characteristics are all other characteristics in table 3. Robust standard errors are in brackets. See appendix M 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.

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 plan 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 even created.[26] To cope with the ongoing war effort in conjunction with the lack of available civilian labor and the German occupation of the North-East industrial départements, the Ministère de la Guerre issued a law in August 1915—one year after the beginning of the war—to withdraw soldiers with manufacturing skills from the front lines, and allocate them to war factories.[27] In this effort, priority was given to older soldiers and fathers of large families. As a result, up to 560,000 soldiers who should have been on the front lines were working in war factories during the conflict.[28] Furthermore, in 1916, the military also started to allocate some of its soldiers into mines to increase steel production. Thus, soldiers from more industrial places, or, equivalently, from less rural ones, had a lower chance of dying in combats.[29] 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 the battle zones. As a result, administrative jobs were mostly given to soldiers from urban areas (Ridel 2007).

Note that 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 is "in excess" in 1911 based on the yearly flows of births and deaths since 1901.[30] When regressing military death rates on this measure, we find that départements that experienced more migration outflows suffered more military fatalities. 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

[26]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).

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

[28]We provide a detailed account of the number of mobilized soldiers outside of armed services throughout the war in appendix table A.4.

[29]Note that the lower death rate in industrial départements induced by the Law Dalbiez was mitigated by the mobilization of soldiers into harvesting from 1917, as labor shortage in the countryside posed a threat to the harvest. 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).

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

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—those undergoing some rural exodus—suffered 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 Ministère de la Guerre 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 the most violent bombardments, I may not receive a scratch" (Remarque 1929).[31]

As we mentioned earlier, the correlations between pre-war characteristics 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 participation. By regressing military death rates on changes in female labor participation before the war, we find that départements that suffered higher military death rates were experiencing a slight relative decline in female labor 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, those départements were subject to a rural exodus. As men and women alike were migrating to urban départements, the labor structure of these départements was slowly changing as well: the size of the industrial sector—and thus formal labor markets—was slowly decreasing. This can explain the relative decline in female labor participation in those areas. When we control for changes in the share of rural population and changes in migration flows, the correlation between pre-war trends in female labor participation and military death rate becomes even weaker (columns 3 and 6). Hence, these slight pre-war differential trends in female labor participation do not invalidate the identification. We later substantiate this claim with a battery of tests to relax the parallel trend assumption.

IV. The Missing Men and Female Labor Participation

A. Baseline Difference-in-Differences Estimates

We first compare relative changes in female labor participation across départements that suffered varying levels of military death rates. To better illustrate how military death rates and changes in female labor participation relate, table 6 compares average labor participation rates in 1911 and 1921 across départements with low, medium and high military death rates.

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

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

Dependent variable:	Military death rate					
	Panel A. 1901-1911			Panel B. 1906-1911		
	(1)	(2)	(3)	(4)	(5)	(6)
Change in FLP	-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

Figure 5 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). *FLP* is the female labor 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. See appendix M 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.

Départements that suffered higher military death rates experienced a larger increase in female labor participation between 1911 and 1921: while female labor participation increased by 5% in départements that suffered low levels military rates, it increased by 21% in départements that suffered high levels of military death rates. Male labor participation remained stable during this time period.

Table 6.
Means in Labor Participation Rates by Level of Military Death Rate (1911-1921)

	1911				1921				% Change (1911-1921)			
	All	Low	Medium	High	All	Low	Medium	High	All	Low	Medium	High
FLP	31.4	34.3	32.4	27.4	35.0	35.2	37.0	32.8	13.9	4.6	15.8	21.3
	(8.9)	(8.7)	(8.6)	(8.3)	(8.3)	(7.7)	(8.2)	(8.8)	(16.2)	(15.6)	(12.1)	(16.5)
MLP	93.2	92.2	94.0	93.4	93.6	92.4	94.4	94.1	0.5	0.2	0.4	0.8
	(2.9)	(2.5)	(1.7)	(3.9)	(3.6)	(4.2)	(2.0)	(4.0)	(2.3)	(3.6)	(1.1)	(1.2)

Table 6 notes: This table presents the means in female and male labor participation rates in 1911 and in 1921. *FLP* female labor participation rate in percents. *MLP* is male labor participation rate in percents. Each group contains 29 départements. The low group has an average death rate of 11.6%, the medium group an average death rate of 15.8%, and the high group an average death rate of 19.3%. Standard deviations are in parenthesis. See appendix M for details about variable sources and definitions.

To make these relative changes more apparent, figure 4 displays the relative trends in female labor participation across the three groups of départements between 1901 and 1936. We normalized the levels of female labor participation to 100 in 1911. Figure 4 shows that départements that suffered higher military death rates experienced a larger increase in female labor participation after the war. Moreover, this gap in female labor participation persisted throughout the interwar period. Importantly, figure 4 confirms that there were no clear differential trends in female labor participation across départements with varying military death rates in the pre-war period, although départements with higher military death rates were experiencing a slight relative decline in female labor participation.

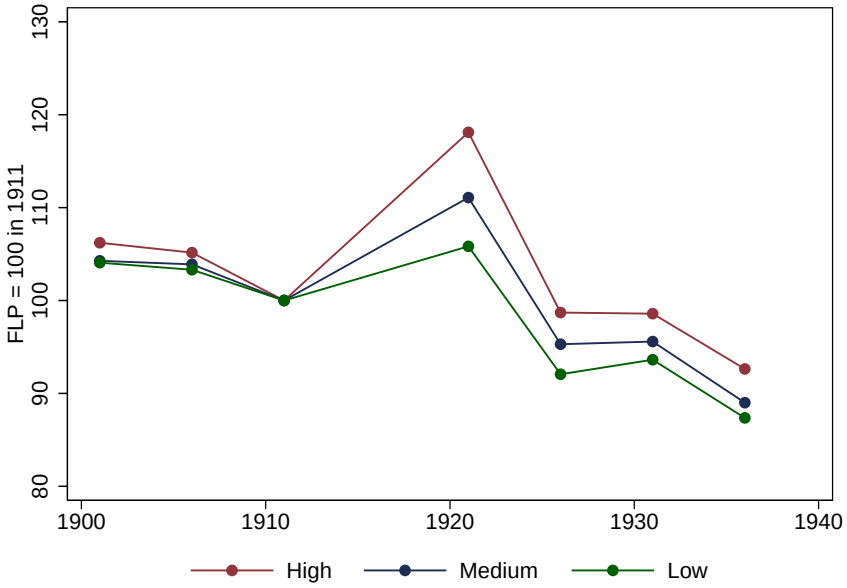


Figure 4. Trends in Female Labor Participation

Figure 4 notes: This figure presents trends in female labor participation. Each line corresponds to a group of 29 départements with a given level of military death rate (high, medium, or low). Female labor participation (FLP) is normalized to 100 in 1911. For the purpose of this picture, we determine group assignment based on the residuals of the regressions of military death rates on pre-war changes in the share of rural population and the share of the residing population born in the département.

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

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

where $\texttt{FLP}_{d,t}$ is female labor participation in département d in year t, $\texttt{death\_rate}_d$ is the

military death rate in département d during the war, $\texttt{post}_t$ is an indicator variable equal to 1 if $t > 1918$, $\boldsymbol{\gamma}_d$ are département fixed effects, and $\boldsymbol{\delta}_t$ are time fixed effects. Moreover, $\mathbf{X}_{d,t}$ is a vector containing the two time-varying characteristics that we described earlier: the share of rural population and the share of the residing population born in the département.

The département fixed effects, $\boldsymbol{\gamma}_d$, allow to control for département-specific unobservable characteristics that are fixed over time and may generate systematic differences in levels of female labor participation. For instance, some départements may have more traditional views regarding gender roles than others, and therefore display systematically lower female labor participation rates. The time fixed effects, $\boldsymbol{\delta}_t$, allow to control for aggregate-level shocks to the labor market that are common to all départements. For instance, labor market conditions were heavily impacted by the economic crisis between 1926 and 1936 (Maruani and Meron 2012). Our results are robust to controlling for regional-level shocks instead—see appendix table A.5, which controls for year times region fixed effects for France's 21 regions. We include changes in rurality and in migration flows as covariates because they may be correlated with changes in female labor participation.[32]

We report the baseline results in panel A of table 7. These imply that in départements that suffered military death rates of 20% rather than 10%, female labor 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 nearly 12% in female labor participation. Put differently, losing 10 men during the conflict induced on average about two women to enter the labor force.[33] 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). Also, we find military fatalities had no effects on male labor participation in the post-war period (panel B).

Effective Sample. To better understand the extent to which each département contributes to the difference-in-differences 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

[32] Many of the other covariates that are available for this time period are likely to be directly affected by military fatalities, such as changes the local structure of the labor market or changes in population levels. As a result, we cannot include them as controls in the regression because they would confound the post-treatment relationship between military fatalities and female labor participation. Note that the measures of rurality may also be impacted by military fatalities. We show that the estimates barely change when including these controls.

[33] For each département, we compute two quantities. First, we compute the number of military fatalities corresponding to a one percentage point in death rate. Second, we compute the number of working women corresponding to a 0.37 percentage point increase in female labor participation rate. Then, we use a product rule, and average the results across départements.

Table 7.
Baseline OLS Estimates

Dependent variable:	Panel A. FLP				Panel B. MLP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Death rate × post	0.37***	0.35***	0.37***	0.35***	0.05	-0.01	0.04	-0.01
	[0.08]	[0.07]	[0.07]	[0.07]	[0.09]	[0.07]	[0.08]	[0.06]
Rural	No	Yes	No	Yes	No	Yes	No	Yes
Born in dép.	No	No	Yes	Yes	No	No	Yes	Yes
Département FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	609	609	609	609	609	609	609	609
Départements	87	87	87	87	87	87	87	87
Within R^2	0.578	0.579	0.579	0.581	0.636	0.669	0.656	0.675
1911 mean	31.4	31.4	31.4	31.4	93.2	93.2	93.2	93.2

Table 7 notes: This table reports the OLS coefficients from estimating specification 2. The dependent variable is female labor participation (*FLP*) in panel A, and male labor participation (*MLP*) in panel B. 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. See appendix M 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.

each unit in the sample. We find that all départements contribute to construct the estimates. Importantly, the relative weight of each département is uncorrelated with its death rate as well as its pre-war characteristics: low and high death rate départements, rural and less rural ones, all equally contribute to the estimates. Note, however, that départements that experienced less migration flows during this period have a slightly larger weight in the regression. Appendix C provides more details.

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. We include leads and lags to assess the plausibility of the parallel trends assumption. We estimate the following specification:

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

where we exclude the year 1911, and where $\texttt{year}_t$ is an indicator variable for each year between 1901 and 1936. The results are shown in panel A of appendix table A.6. The estimates are stable throughout the interwar period as they range between 0.38 and 0.44 (column 1). To provide a visual impression of their stability throughout the period, we plot the year-specific estimates in figure 5. Again, adding the control variables barely changes the estimates (columns 2-4). These results suggest that military fatalities induced some women to enter the labor market after the war, and that these women remained in the labor force. Finally, we also find that military fatalities had no effect on male labor participation (panel B).

Importantly, the coefficients on pre-war years are not significant, suggesting that differential trends in pre-war female labor participation are not driving the results. They are nonetheless slightly positive: for instance, the baseline coefficient on the lead of 1906 is 0.04 (column 1), with a standard error of the same magnitude. This implies that départements that suffered higher death rates had a relative downward trend in female labor participation before the war, which could bias the baseline estimates downward. Based on the results in the previous section, we interpret this potential downward bias as a result of the correlation between unobservable determinants of migration patterns and pre-war trends in female labor participation.

Estimates by Sector of Activity. We also decompose the response of female labor to military fatalities by sector of activity, and find that most of the effect identified stems from women working in domestic services and in the industrial sector. Compared to pre-war levels, the magnitude of the impact is similar across both sectors: in départements that suffered military death rates of 20% rather than 10%, female labor participation in both the domestic services and the industrial sector increased by about 20% compared to pre-war levels. The analysis is presented in appendix I.

B. Relaxing the Parallel Trends Assumption

We propose four solutions to relax the parallel trends assumption and mitigate the potential bias resulting from the downward pre-war relative trend in female labor participation in higher death rates départements. First, we verify that differential trends in female labor participation across départements are not affecting the results by controlling for département-specific time trends. Second, we allow for time-varying heterogeneity across groups of départements. Using Bonhomme and Manresa's (2015) grouped fixed effects algorithm, we do not impose any *a priori* structure on the group assignment. Third, we use

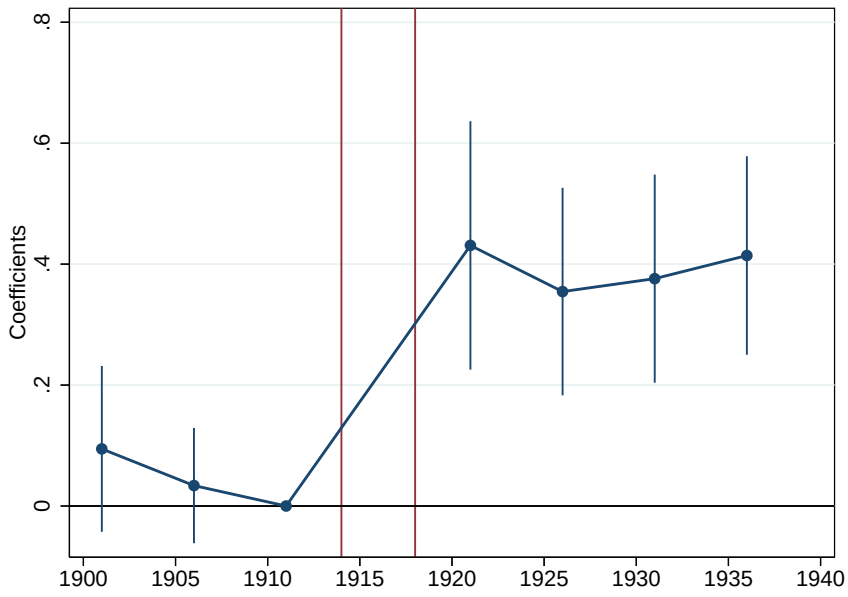


Figure 5. Year-Specific OLS Estimates

Figure 5 notes: This figure reports the year-specific OLS estimates of column 4 in table A.6. The blue lines represent 95% confidence intervals around the estimates.

exogenous variations in military death rates across départements as an instrument along with the difference-in-differences strategy. Finally, we run the analysis separately on groups with similar pre-war observable characteristics. All results are similar to the baseline estimates, suggesting that the parallel trends assumption is appropriate in this context.

Controlling for Département-Specific Time Trends. We extend the baseline specification in equation 2 and control for département-specific time trends in female labor participation. We first impose linear time trends and estimate the following specification:

$$\texttt{FLP}_{d,t} = \beta\, \texttt{death\_rate}_d \times \texttt{post}_t + \boldsymbol{\lambda}_d \cdot t + \boldsymbol{\theta}'\, \mathbf{X}_{d,t} + \boldsymbol{\gamma}_d + \boldsymbol{\delta}_t + \varepsilon_{d,t}, \tag{4}$$

where $\boldsymbol{\lambda}_d \cdot t$ is the département-specific linear time trend. The results are presented in columns 1 and 2 of table 8. All the coefficients are significant at the 1% level. Moreover, they are only slightly larger than the baseline estimates presented in table 7: the coefficients from this specification imply that in départements that suffered a military death rate of 20% rather than 10%, female labor participation was 4 percentage points higher in the interwar period. This suggests that pre-war differential trends in female labor participation slightly biased the baseline estimates downward. Adding quadratic, cubic, or quartic time trends in

columns 3-8 generates similar results.

Table 8.
Département-Specific Time Trends

Dependent variable:	Female Labor Participation (LFP)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Death rate × post	0.41***	0.40***	0.47***	0.46***	0.47***	0.47***	0.47***	0.47***
	[0.15]	[0.15]	[0.16]	[0.16]	[0.16]	[0.16]	[0.16]	[0.16]
Rural	No	Yes	No	Yes	No	Yes	No	Yes
Born in dep.	No	Yes	No	Yes	No	Yes	No	Yes
Département FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Département × year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Polynomial order	1	1	2	2	3	3	4	4
Observations	609	609	609	609	609	609	609	609
Départements	87	87	87	87	87	87	87	87
Within R^2	0.821	0.824	0.869	0.873	0.869	0.873	0.869	0.873
1911 mean	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4

Table 8 notes: This table reports the OLS coefficients from estimating specification 4 in columns 1 and 2, and expanding the time-trend polynomial. The dependent variable is female labor participation. 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. See appendix M 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.

Furthermore, we relax the assumption that military fatalities had a constant effect across time and compute year-specific coefficients by estimating the following specification:

$$\texttt{FLP}_{d,t} = \sum_{\tau=1906}^{1936} \beta_\tau \, \texttt{death\_rate}_d \times \texttt{year}_\tau + \boldsymbol{\lambda}_d \cdot t + \theta' \, \mathbf{X}_{d,t} + \boldsymbol{\gamma}_d + \boldsymbol{\delta}_t + \varepsilon_{d,t}, \tag{5}$$

where we exclude 1901 to estimate the trends. We report the results in appendix table A.7. As before, the coefficients are stable across time and significant at the 1% level. Again, the estimates are only slightly larger than the baseline estimates presented in table A.6.

Grouped Fixed Effects. It is possible that some départements displayed differential time patterns in female labor participation and biased the baseline estimates downward. To alleviate this concern, we inspect the robustness of the baseline specification to allowing

for time-varying heterogeneity across groups of départements. More specifically, we relax the assumption that time fixed effects are common to all départements by estimating the following specification:

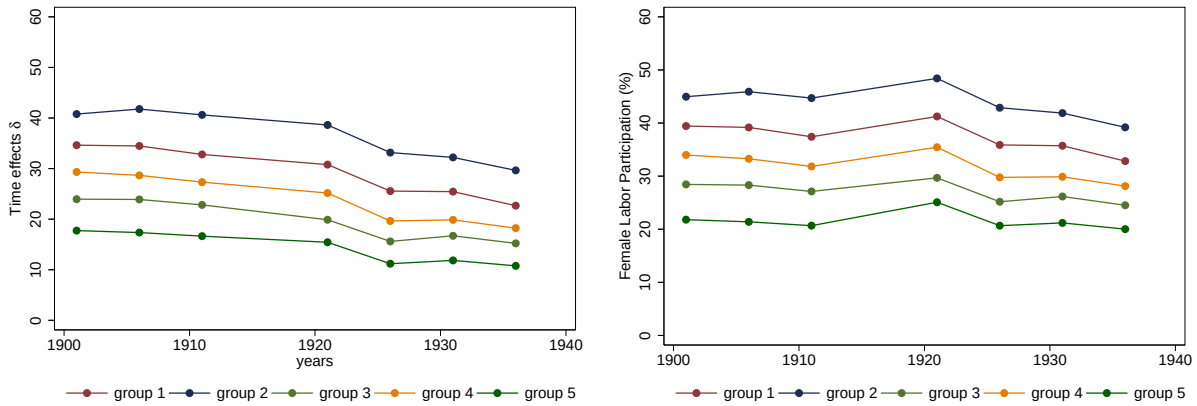
$$\texttt{FLP}_{d,t} = \beta\ \texttt{death\_rate}_d \times \texttt{post}_t + \boldsymbol{\theta}'\ \mathbf{X}_{d,t} + \boldsymbol{\gamma}_d + \boldsymbol{\delta}_{g_d,t} + \varepsilon_{d,t}, \tag{6}$$

where g_d represents département d's group membership, and $\delta_{g_d,t}$ denotes the group specific time effects. Importantly, we do not impose any *a priori* structure on group membership such as geographic clustering. Instead, we estimate group membership from the data by using Bonhomme and Manresa's (2015) grouped fixed effects algorithm. Conditional on specifying the total number of groups, the algorithm optimally groups départements with the most similar time profiles in female labor participation, net of the correlation with military death rates and other covariates. By controlling for differential time patterns in female labor participation across groups, we can effectively relax the parallel trends assumption.

To illustrate this point more clearly, we set the number of groups to 5 and plot the grouped fixed effects $\widehat{\delta}_{g_d t}$ in panel (a) of figure 6. All five groups have parallel time patterns, suggesting that using a single time fixed effect is justified. Moreover, they do not display any differential time pattern in female labor participation rates when the effect of military fatalities and départements characteristics are accounted for —see panel (b) of figure 6. This suggests that the parallel trends assumption across all départements is reasonable in this context. Appendix figure B.1 shows the estimate $\widehat{\beta}$ of equation 6 for up to 10 groups. Allowing for heterogeneity in the time pattern of female labor participation does not alter the baseline results much with all coefficients close to 0.3.

Instrumental Variables Strategy. We use exogenous variation in military death rates as an instrument in a difference-in-differences framework. The instrumental variables strategy relies on the recruitment process of the army. At the onset of the war, in 1914, the *active army* was constituted by four age cohorts: the men between the ages 20 and 23.[34] To follow the vocabulary of the army, we designate an age cohort by the year in which it was recruited by the army, i.e., the year when members of that cohort reached the age of 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 military training, and was

[34]Following the military conscription law of 1913, the 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*—see appendix table A.1 for the length of service in each of those armies.



(a) Group Fixed Effects

(b) Female Labor Participation

Figure 6. Patterns of Grouped Heterogeneity

Figure 6 notes: The estimation of the grouped fixed effects $\widehat{\delta}_{g_d t}$ in panel (a) and trends in female labor participation in panel (b) follow Bonhomme and Manresa's (2015) grouped fixed effects algorithm.

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 a different level of military training when the war begun, but they were sent to the same battlefields, within the same military units. The class of 1911 had completed three years of military training, the class of 1912 had completed two years, and the class of 1913 had completed one year. The class of 1914 had only three months of training. 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.[35] We argue that these differences are essentially due to differential levels of military training across the classes of 1911 to 1914.

Other reasons could potentially explain the differential death rate across these four classes. First, members of each class could have differential initial physical or intellectual abilities. Appendix table A.8 shows that members of each class had similar heights and education levels at age 20, rejecting this possibility.[36] A second reason might be that averaging yields the observed pattern: if older soldiers died at lower rates because of better physical abilities than younger soldiers, then averaging death rates over an entire class could yield the pattern observed in the data. To verify that differences in death rates across classes are not driven by such an averaging effect, figure 7 plots the number of military fatalities

[35]More precisely, the class of 1911 contributed 5.7% to the overall death rate, the class of 1912 contributed 6.2%, the class of 1913 contributed 6.5%, and the class of 1914 contributed 6.7%.

[36]The data are from the *Rapports sur le recrutement de l'armée* for the years 1909, 1910, 1911, 1912, 1913, and 1914. We also show that those age classes are similar along these dimensions to older age classes.

by month of birth across these four classes. It shows that differences in fatalities by class are not driven by an averaging effect as regression lines do not display a positive slope. In fact, soldiers born earlier in the year seem to die at higher rates.[37] A third reason might be that older soldiers were more likely to be of higher military rank, and were therefore less likely to be sent on the battlefield. Indeed, the mechanism of promotion in the army was partly based on seniority.[38] As a result, it is possible that soldiers that entered the army earlier moved up the ranks faster. This, in turn, could have decreased their probability of dying on the battlefield: Guillot and Parent (2015) show that higher ranked soldiers had a longer life expectancy during the war, although the effect is small.[39] This last reason does not invalidate the instrumental variables strategy as it is still the year of birth—either by increasing the length of training or increasing seniority and thereby the likelihood of faster promotion—that creates an exogenous discontinuity in the probability of dying during the war.

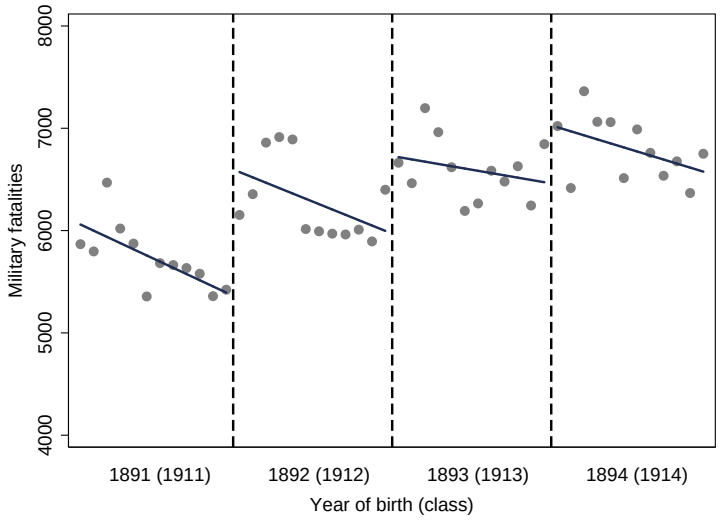


Figure 7. Military Fatalities by Month of Birth, Classes 1911 to 1914

Figure 7 notes: Each gray dot represents the number of military fatalities for soldiers born during the same month of the same year. The blue lines are regression lines for each class.

[37]This is not driven by cyclical birth patterns, as the same pattern holds when we weight fatalities by the number of birth in each month.

[38]The promotion system of the army during WWI followed the principles of the *Ordonnance* of March 16th, 1838, which required at least 6 month in a given rank to have the opportunity to move up to a higher rank—this was the case for lower ranks of the army such as soldier of 1st class and corporal (*Ordonnance du 16 mars 1838 sur l'avancement dans l'armée*, Title II, Chapter I, art. 11, p. 18).

[39]For instance, conditional on dying during the war, a 1st class soldier lived on average 60 days longer than a 2nd class soldier. Similarly, a corporal (the rank just above 1st rank soldier) lived on average 91 days longer than a 2nd class soldier (Guillot and Parent 2015, p. 19).

The instrumental variables strategy builds on these discontinuities. Ideally, we would like to compute the relative size of the male population born in December of a given year t compared to the size of the male population born in January of year $t+1$. According to our reasoning, men born "by chance" in December should die at lower rates than the men born in January because they got an additional year of training for plausibly exogenous reasons. However, the census of 1911 only provides information on the male population by year of birth in each département, not by month of birth. This allows us to build three instruments, each instrument representing the relative size of a class compared to the following class. For instance, the relative size of the class of 1913 with respect to the class of 1914 is calculated as:

$$\texttt{ratio\_class}_{\texttt{1913-1914},d} = \frac{\texttt{male\_population\_of\_class\_1913\_in\_département\_d}}{\texttt{male\_population\_of\_class\_1914\_in\_département\_d}} \times 100, \quad (7)$$

with population data from the census of 1911.

We verify in appendix H that the results are not sensitive to alternative specifications of the instruments: we obtain similar results when using the size of a given class compared to the size of the male population of all four classes, or when using the size of a given class compared to the size of the class of 1910.

The set of instrumental variables we use is based on département-specific demographic characteristics. As a result, the instruments could be systematically correlated with unobserved determinants of the rural exodus, which are themselves correlated with differential trends in female labor participation across départements. Consider the case of a département characterized by a strong rural exodus. It may be possible that, as they get older, mean leave their département to find a job in another, more urban, département.[40] This would in turn change labor market conditions for women, for instance by inducing a decline in the size of the industrial sector. Older cohorts in those départements would then be systematically smaller than younger ones in a given year. In this case, the instruments would not be independent of potential outcomes and the exclusion restriction would be violated. We explore this possibility by first computing the correlation across the three instruments and find coefficients of correlation that range from 0.16 to 0.31. This suggests that the determinants of the relative size of successive cohorts are not systematically correlated. We then explore the dynamic pattern of the instruments within each département. We find that the instruments do not follow a deterministic trajectory in 60% of the cases, i.e., consecutive cohorts are

[40]The largest part of internal migrations in France around that time were micro-migrations within rural areas (Bourdieu et al. 2000, Kesztenbaum 2014).

neither systematically decreasing nor increasing in size.[41] If the instruments were randomly assigned, we would not find any systematic pattern in 75% of the cases.[42] Finally, we check in appendix table A.10 that the instruments are not correlated with pre-war trends in female labor participation. All these tests support the idea that the instruments are unrelated to unobservable determinants of migration patterns before the war and that the exclusion restriction is unlikely to be violated.[43]

We verify that the instruments are correlated with the distribution of military death rates by estimating the following first-stage specification for each instrument:

$$\texttt{death\_rate}_d \times \texttt{post}_t = \phi\, \texttt{ratio\_class}_d \times \texttt{post}_t + \boldsymbol{\kappa}'\, \mathbf{X}_{d,t} + \boldsymbol{\mu}_d + \boldsymbol{\eta}_t + \varepsilon_{d,t}. \tag{8}$$

where $\boldsymbol{\mu}_d$ are département fixed effects, and $\boldsymbol{\eta}_t$ time fixed effects. The estimates are reported in table 9. As expected, the higher the size of a class relative to the next one, the lower the death rate. Moreover, the instruments are strong: the F-statistic are above 10 all three instruments (columns 1-3), and is about 27 when we use all three instruments together (column 4). In addition, figure 8 shows the first-stage estimates for all other class ratios. It shows that only the instruments we propose yield a credible first-sage. This supports the idea that the four classes we consider were uniquely affected by differential training levels.

We instrument the death rate in equation 2 with the relative size of consecutive classes. The main results are reported in table 10. For reference, column 1 displays the baseline OLS estimate from column 4 in table 7. The coefficient in column 5 suggests that the baseline OLS estimates were biased downward because of a slight pre-war differential trend in female labor participation in départements with high military death rates. The instrumental variable results imply that in départements that suffered a military death rate of 20% rather than 10%, female labor participation was 5.4 percentage points higher in the interwar period. Again, only the class ratios we consider generate meaningful results—see appendix figure B.2. All these results are robust to alternative specifications of the instruments—see appendix H.

Analysis on Separate Sub-Groups. Finally, we split the sample in halves along pre-war

[41] We provide the full patterns in appendix table A.9.

[42] If instruments were randomly assigned, each instrument would be above one 50% of the time. As a result, all three instruments being above one would have a probability of one eighth. Therefore, a systematic pattern of all instruments being above one *or* all instruments being below one would emerge 25% of the time.

[43] A scenario would be that the imbalances in successive cohorts sizes affected the post-war female labor market conditions through the disruption in the post-war marriage market. It would be the case if females were only mating with men from their own cohort, which is unlikely.

Table 9.
First-Stage Estimates

Dependent variable:	Death rate × post			
	(1)	(2)	(3)	(4)
Ratio class 1911-1912 × post	-0.28***			-0.17***
	[0.05]			[0.03]
Ratio class 1912-1913 × post		-0.39***		-0.31***
		[0.05]		[0.06]
Ratio class 1913-1914 × post			-0.31***	-0.20***
			[0.10]	[0.05]
Rural	Yes	Yes	Yes	Yes
Born in dép.	Yes	Yes	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	0.959	0.967	0.955	0.974
F-statistic	29.11	55.75	10.62	27.30

Table 9 notes: This table presents the OLS coefficients from estimating specification 8. The dependent variable is military death rates. 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. See appendix M 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.

observable characteristics. We select the characteristics along which départements with varying levels of military death rates were systematically different—see table 3. We then run the analysis separately on these subsamples, which renders the parallel trends assumption even more plausible. The results are reported in appendix table A.11, where each cell represents the estimate from a separate regression. Panel A shows the results when using the OLS estimation strategy, and panel B when using the instrumental variables strategy. For reference, the first line shows the baseline estimates from tables 7 and 10. All 64 estimates have the expected sign, and all but four are significant at conventional levels. The estimates display heterogeneity in the response to military fatalities across départements: in general, female labor participation responded more to military fatalities in départements that were more urban, more industrial, and wealthier.

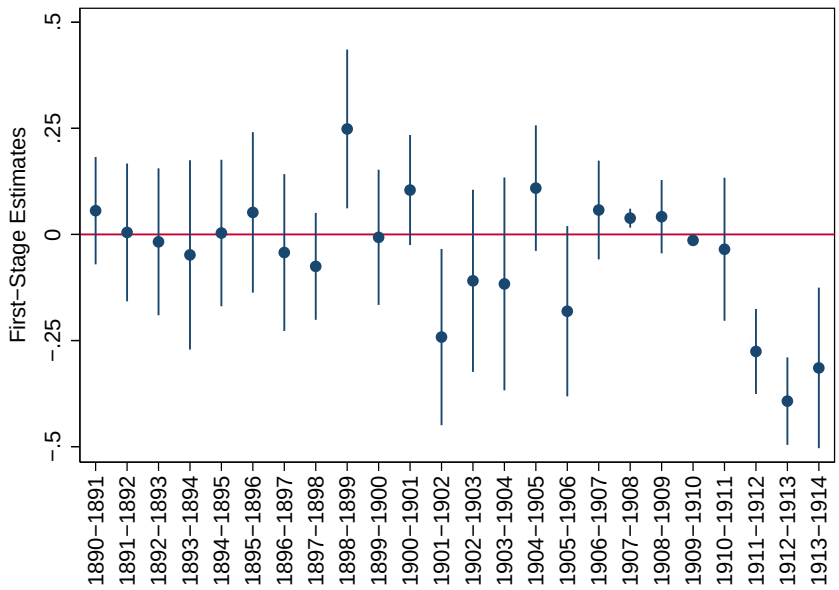


Figure 8. First-Stage Estimates, All Class Ratios

Figure 8 notes: Each category is a class ratio as defined in equation 7. For instance, `1890-1891` is the ratio of the class 1890 to the class 1891. The blue lines indicate 95% intervals around the estimate.

C. Other Robustness Checks

Spatial Correlation Across Départements. As apparent in figure 3, military death rates look spatially clustered. We discussed in section III how both the geography of the organization of the army in 1914 and the policies of the Ministère de la Guerre 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. In appendix J, we show that the results are robust to other forms of spatial correlation. First, we replicate the results when using larger clusters related to the distribution of military death rates: clusters at the administrative region level, and clusters at the military region level. There are 21 administrative regions, and 22 military regions. In both cases, standard errors are similar to the ones obtained when clustering at the département level. Moreover, although the degree-of-freedom adjustment is more strict, all the results are significant at similar levels. Second, we follow Conley (1999, 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 km, 500 km, and 750 km cutoffs. Given the average size of French départements, the 500 km cutoff approximately corresponds to allowing a correlation between each département and its twenty neighboring départements. In all cases, the standard errors corrected for spatial correlations are smaller than the clustered standard errors and

Table 10.
Instrumental Variables Estimates

Dependent variable:	Female Labor Participation (FLP)				
	OLS	IV			
	(1)	(2)	(3)	(4)	(5)
Death rate × post	0.35***	0.80***	0.48***	0.37**	0.54***
	[0.07]	[0.22]	[0.14]	[0.18]	[0.13]
Instrument	No	1	2	3	1-3
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	609	609	609	609	609
Départements	87	87	87	87	87
Within R^2	0.581	0.507	0.575	0.581	0.567
1911 FLP mean	31.4	31.4	31.4	31.4	31.4

Table 10 notes: This table reports the IV coefficients from estimating specification 2 with the class ratio instruments. *Instrument 1* is the ratio of the class 1911 to the class 1912, *Instrument 2* is the ratio of the class 1912 to the class 1913, and *Instrument 3* is the ratio of the class 1913 to the class 1914. Column 1 reports the baseline OLS estimate from column 4 in table 7. 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. See appendix M 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.

the significance levels are similar.

The Impact of War Départements. War combats directly affected eleven départements in the industrial North-East part of France—see figure 3. 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 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 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 correlation between military fatalities and the intensity of the reconstruction effort could therefore bias the estimates upward. The net impact on the estimates 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. We propose two strategies to cope with this potential problem. First, we replicate the analysis when excluding these eleven départements. Then, we collect historical data from Michel (1932) and directly check whether military fatalities are correlated with the extent of war destructions and the intensity of the reconstruction effort. Both strategies show that war départements are not driving the results. Excluding these départements from the analysis does not affect the results. Moreover, we find no correlation between military death rates and war destructions or the intensity of the reconstruction effort.

Alternative Measure of Female Labor Participation. As mentioned in section A, wives of farmers were inconsistently recorded as active across départements in 1901, and they accounted for almost all female chefs d'établissement in farming. We systematically exclude these women from the data in order to properly examine pre-war trends in female labor participation. In appendix D, we replicate the main results of the paper when including female chefs d'établissements in farming and find similar results.

Correcting Military Death Rates for Pre-War Migration Patterns. As described in section B, we determine the number of military fatalities in a département by using soldiers' département of birth. Pre-war migration patterns could bias the results. For instance, suppose that prior to the war, many men from rural départements migrated to urban départements. We would then falsely attribute some military fatalities to rural départements instead of urban départements. The effect of military fatalities on female labor participation would then be attributed to the missing men although the actual reason for the pattern in the data would lie in the determinants of these migration patterns between rural and urban départements. In appendix F, we construct an alternative measure of military death rates by taking into account bilateral migration flows across départements in the census of 1911. We then replicate the main results of the paper, and find very similar estimates.

Pre-War Health Conditions and Differential Enlistment Rates. As described in section B, using the male population aged 15 to 44 in 1911 may not adequately capture the pool of drafted men. Indeed, not all men subject to military conscription were enlisted in the army, as "only" 78.5% of 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. This could be problematic in two ways. First, even if military fatalities and pre-war health conditions were orthogonal, our results could be biased downward in the following way. We assume that the pool of drafted men is composed by all men aged 15 to 44 in 1911. Suppose that 20% of these men were physically too weak to be recruited, as well as "unfit" to work properly in war factories, and to have a good standing in the marriage market. As a result, we would be underestimating the real military death rate, and our main results would be biased downward. Second, it is possible that military fatalities and pre-war health conditions were correlated, i.e., that conditional on the actual pool of drafted men, départements with relatively worse pre-war health conditions suffered higher military fatalities. If this was the case, and if we were unable to control for these differential pre-war health conditions, part of the effects we are identifying would be attributable to pre-war differences in health conditions rather than military death rates. To deal with this issue, we explore in appendix G the determinants of differential enlistment rates in the army 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. However, the two baseline controls in the analysis are sufficient to capture the differences in pre-war health conditions that might affect the rate of military fatalities.

Population-Weighted Regressions. In appendix K, we replicate the main results of the paper when using département population as weights in the regressions. All the results are in line with the ones obtained through unweighted regressions.

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 that suffered 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 participation could partially be attributed to some women leaving low death rate départements for high death rate départements. Appendix figure B.3 shows the national trends in female migration patterns. The share of the 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 mobile labor may confound the results. Nevertheless, to address this potential concern, we run specification 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—coefficient of 0.08, and standard error of 0.11.

V. Investigating the Mechanisms

We have documented the effect of military fatalities on female labor participation in the interwar period. We now investigate the mechanisms underlying this effect. Both changes in supply and demand for female labor could account for the pattern we find in the data. Military fatalities could have induced women to increase their supply of labor for three reasons. First, young 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.[44,45] Second, the 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 (Chiappori et al. 2002, 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. 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—see appendix figure B.4 for a simulation of the real income of single working women, single mothers, and war widows in the interwar period.[46] 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 successively explore whether supply and demand factors can explain the pattern we find in the data. Within the limits of the data available for this time period, we find that the most plausible channel consists of supply factors: single women entering the labor force while searching for a husband, and war widows working to compensate for the loss of their husbands' incomes. We also show that the rise in female labor participation *during* the war cannot explain the post-war entrance of women in the labor force. Finally,

[44] State subsidies to single mothers were relatively low. As a result, women did not see single motherhood as a third option, leaving working as a single woman and getting married as marginal choices (Neal 2004). For instance, an average working women in 1921 earned about seven times as much as a single mother with two children relying on State subsidies. To support this point, appendix figure B.4 simulates the real income for single working women, single mothers, and war widows.

[45] Historical accounts support the idea that the market place was a platform to meet a husband. For instance, a female factory superintendent tells 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).

[46] Note that State subsidies to war widows sharply increased at the end of the interwar period: in 1931, subsidies to war widows increased to about 75% of the labor income of an average working women.

we show that changes in beliefs about gender roles—measured by changes in voting patterns of *députés* at the Assemblée Nationale regarding female suffrage extension before and after the war—cannot account for the rise in female labor participation after the war.[47]

A. Supply Factors: the Marriage Market and Adverse Income Shocks

To assess the effect of military fatalities on female labor participation through labor supply channels, we transcribed marital status data from the seven French censuses from 1901 to 1936. Summary statistics for the share of the female population of each marital status are provided in appendix table A.12. The share of single women sharply increased after the war, especially among the 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.

Military Fatalities and Marriage Market Outcomes. We first document how military fatalities tightened the post-war marriage market, and then identify how this in turn impacted female labor participation. 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 on the marriage market as men became more scarce. As a result, women were less likely to marry after the war in départements that suffered relatively more military fatalities. We expect that a significant share of the women who did not marry because of the war entered the labor force after the war. Moreover, we expect that some women who became widows as a result of the war also entered the labor force to compensate for the loss of their husbands' incomes.[48]

To analyze the impact of military fatalities on the interwar marriage market, we estimate the following specification for various age groups and marital statuses:[49]

[47] The Assemblée Nationale is the French lower house—France has a bicameral Parliament. The members of the Assemblée Nationale are the *députés*.

[48] A comparable phenomenon has been documented by Salisbury (2017) in the case of widows of the U.S. Civil War.

[49] These regressions extend one of the main results in Abramitzky et al. (2011, p. 136). However, the marital statuses "widowed" and "divorced" are not available separately except in the censuses of 1911 and 1921. Moreover, the ages were recorded differently in the 1906 census, so we exclude this year from the sample. As a result, the sample consists of the following census years: 1901, 1911, 1921, 1926, 1931, and 1936. We reproduce the results presented in Abramitzky et al. (2011, p. 136) in appendix table A.13. Note that we do not exactly reproduce their table because we focus on the marital status of women only, and we add the share of married women as an outcome variable. We also cluster standard errors at the département level.

$$\mathtt{Y}_{a,d,t} = \beta\ \mathtt{death\_rate}_d \times \mathtt{post}_t + \theta'\ \mathbf{X}_{d,t} + \gamma_d + \delta_t + \varepsilon_{a,d,t}, \tag{9}$$

where $\mathtt{Y}_{a,d,t}$ is the share of the female population of a particular marital status in age group a, département d, and year t. Again, $\mathtt{post}_t$ is an indicator variable for $t > 1918$. We report the results in table 11. The estimates are very similar to those in Abramitzky et al. (2011, p. 136), suggesting that their analysis is robust to increasing the sample to the entire interwar period, and to including more pre-war years. Overall, we find that women in départements that suffered higher military death rates were more often single (panel A) and widowed (panel B) after the war. In particular, our results imply that in départements that suffered a military death rate of 20% rather than 10%, the proportion of single women aged 20 to 29 was 2.7 percentage points higher, compared to an average of 38.9 in 1911 (column 1).[50] The effect is smaller for older women. Moreover, we find that women aged 40 to 49 were most likely to lose their husbands during the war.[51]

Data to explore the labor supply channels in more details are scarce. For instance, the censuses do not provide information on labor participation by sex and 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 about changes in the shares of single and widowed women. The results can therefore only be suggestive, and their credibility will rely upon the validity of the assumptions we are willing to impose on the data. Nevertheless, the lack of data on labor participation of married women is not as problematic as it seems, as national trends in female labor participation suggest that single and widowed women drove the overall increase in female labor in the interwar period: while the labor participation rates of married women remained roughly constant between 1911 and 1921, the participation rates of single and widowed women increased respectively from 67% to 70%, and from 37% to 43%. Appendix figure B.5 shows the national trends in the share of women in the labor force for each marital status between 1901 and 1936.

The Marriage Market as a Transmission Channel. To study the effect of military fatalities

[50] We find estimates similar to Abramitzky et al. (2011, p. 136, table 2, column 2, row 2), although our coefficient is slightly more precisely estimated.

[51] 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. The 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. However, we do not find any correlation between changes in marriage flows and changes in female labor participation.

Table 11.
Female Marital Status

Dependent variable:	Panel A. Single (%)			Panel 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

Table 11 notes: This table reports the OLS coefficients from estimating specification 9. 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. See appendix M 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.

on female labor participation through changes in marriage market conditions, we use tools from the causal mediation framework.[52] We assume throughout that single women and war widows were in different marriage markets. For instance, we rule out the possibility that war widows competed against young single women for a husband in the interwar period. This assumption seems reasonable as war widows and young single women pertained to different cohorts, and so did their potential husbands. Moreover, there is historical evidence that most war widows did not re-marry.[53] To render this assumption more plausible, we focus on the younger single women (aged 20 to 29) and on the older widows (aged 30 to 49), which were effectively in different marriage markets: for instance, in 1921, while 83% of marriages of widows aged 30 to 49 involved a male spouse older than 30, 73% of of marriages

[52]This framework is presented in Imai et al. (2011), Imai and Yamamoto (2013), and Imai et al. (2013).
[53]By 1923, about 140,000 war widows out of 600,000 were remarried, i.e., about 23% of war widows (Petit 2007, p. 129).

of single women aged 20 to 29 involved a male spouse younger than 30. To support this point, appendix figure B.6 shows the evolution of the distribution of the age of male spouses for these two categories of women between 1907 and 1936.

Under this assumption, we estimate the causal relationship between changes in marriage market conditions and changes in female labor participation due to the war using the following three equations:

$$\begin{cases} \texttt{single}_{d,t} &= \beta_S \, \texttt{death\_rate}_d \times \texttt{post}_t + \theta'_S \, \mathbf{X}_{d,t} + \gamma_{S,d} + \delta_{S,t} + \varepsilon_{S,d,t} \\ \texttt{widowed}_{d,t} &= \beta_W \, \texttt{death\_rate}_d \times \texttt{post}_t + \theta'_W \, \mathbf{X}_{d,t} + \gamma_{W,d} + \delta_{W,t} + \varepsilon_{W,d,t} \\ \texttt{FLP}_{d,t} &= \beta_1 \, \texttt{death\_rate}_d \times \texttt{post}_t + \beta_2 \, \texttt{single}_{d,t} + \beta_3 \, \texttt{widowed}_{d,t} + \theta' \, \mathbf{X}_{d,t} + \gamma_d + \delta_t + \varepsilon_{d,t}. \end{cases} \tag{10}$$

$\texttt{single}_{d,t}$ denotes the proportion of single women aged 20 to 29 in département d at time t. $\texttt{widows}_{d,t}$ denotes the proportion of widowed women aged 30 to 49. The quantities of interest are $\hat{\beta}_2 \times \hat{\beta}_S$ and $\hat{\beta}_3 \times \hat{\beta}_W$.[54] These quantities provide the effect of military fatalities on female labor participation through each channel under a modified version of the "sequential ignorability" assumption (Imai and Yamamoto 2013): we must be willing to assume that (1) there are no differential trends in labor and marriage market outcomes across départements with varying levels of military death rates, and that (2) conditionally on military death rate, there are no differential trends in labor market outcomes across départements with varying levels of marriage market outcomes. In the next paragraphs, we explain why it is reasonable to impose these assumptions in our context, and then provide some baseline estimates.

The first set of assumptions is similar to the parallel trends assumption in a difference-in-differences design. We already showed that this is a reasonable assumption relative to labor market outcomes. To explore its validity relative to marriage market outcomes, appendix figure B.7 shows the relative trends in the share of single women aged 20 to 29 (panel (a)), and in the share of widowed women aged 30 to 49 (panel (b)) across groups of varying levels of military death rates. We standardize the levels of each outcome variable to 100 in 1911 to make the relative trends more apparent. There are no pre-war differential trends in the share of single women. Regarding widows, départements that suffered higher military death rates had a slight declining trend in the share of widowed women before the war. This suggests that the baseline estimates of the effect of military fatalities on the proportion of widows

[54] An alternative way would be to add interactions to the third equation and only 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 method implicitly assumes that the effect of military fatalities on female labor through marriage market outcomes was heterogeneous across levels of military death rates, which need not be the case. See Imai et al. (2011, p. 784) for more details.

could be biased downward.

To check that pre-war differential trends do not drive the effect of military fatalities on post-war marriage market outcomes, we use the same strategy as before: we compute year-specific estimates, control for département-specific linear trends, and combine the difference-in-differences approach with an instrumental variable approach. First, we estimate the following difference-in-differences specification:

$$\mathtt{Y}_{a,d,t} = \sum_{\substack{t=1901 \\ t \neq 1911}}^{1936} \beta_t \, \mathtt{death\_rate}_d \times \mathtt{year}_t + \theta' \, \mathbf{X}_{d,t} + \gamma_d + \delta_t + \varepsilon_{a,d,t}, \tag{11}$$

where $\mathtt{Y}_{a,d,t}$ is the share of single women aged 20 to 29, *or* the share of widowed women aged 30 to 49 in département d at time t. Moreover, we exclude the year 1911, and include a lead (1901) to assess whether the results are driven by pre-war differential trends in marriage market outcomes.[55] We report the results in appendix table A.14. The coefficients on the leads in all the columns suggest that pre-war trends in marriage market outcomes do not drive the results as they are close to zero and not significant at conventional levels across all marital statuses and all age groups. Moreover, the stability of the estimates suggest that military fatalities affected marriage market outcomes throughout the interwar period. Also, all the coefficients are in line with the results in table 11 and statistically significant at the 1% level in post-war years.

Table 12 reports the results from estimating equation 9 when controlling for département-specific linear trends (columns 2 and 5), and when using the instrumental variables strategy (columns 3 and 6). Controlling for linear time trends yields the same results as the baseline estimates in columns 1 and 4 for both types of women. The instrumental variables estimates are also in line with the baseline estimates. Overall, our results suggest that the parallel trend assumption for marriage market outcomes is reasonable in this context.

The second set of assumptions is that there are no differential trends in female labor participation across départements with varying levels of marriage market outcomes conditional on similar levels of military death rates. Exploring the validity of this assumption is difficult as all units have different levels of military death rates. However, this set of assumptions seems credible as départements with similar military death rates also display similar levels and trends in female labor participation before the war. For instance, we show in appendix figure B.8 that the trends in female labor participation across départements with medium death rates but low and high marriage market outcome were the same in the case of single women aged 20 to 29. For widows, it seems that départements with medium death rates and

[55] As mentioned in footnote 49 on page 37, we do not have comparable marital status data for 1906.

Table 12.
Female Marital Status, Robustness

Dependent variable:	Panel A. Single 20-29 (%)			Panel B. Widows 30-49 (%)		
	OLS		IV	OLS		IV
	(1)	(2)	(3)	(4)	(5)	(6)
Death rate × post	0.27***	0.28***	0.38***	0.12***	0.11***	0.14***
	[0.07]	[0.07]	[0.08]	[0.03]	[0.04]	[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
Département × Year	No	Yes	No	No	Yes	No
Observations	522	522	522	522	522	522
Départements	87	87	87	87	87	87
Within R^2	0.824	0.943	0.822	0.839	0.921	0.839
1911 mean	38.9	38.9	38.9	8.0	8.0	8.0

Table 12 notes: This table reports the OLS and IV coefficients from estimating specification 9. The instruments are the class ratios. The dependent variable is the share of single women aged 20 to 29 in panel A, and the share of widowed women aged 30 to 49 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. See appendix M 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.

low share of widows had a slight declining relative trend in female labor participation.

Table 13 reports the estimates of the third equation of specification 10 using three different strategies: the baseline (panel A), controlling for département-specific linear time trends (panel B), and using an instrumental variable strategy (panel C). Estimating this equation generates two types of interesting quantities: first, it shows how the coefficient on military death rates ($\widehat{\beta}_1$) changes onces we include marriage market outcomes in the equation.[56] Second, it describes the effect of changes in the marriage market on female labor market outcomes ($\widehat{\beta}_2$ and $\widehat{\beta}_3$).

[56]We reproduce the following coefficients for means of comparison, except that we exclude year 1906 to run the analysis on similar samples: the coefficient in panel A, column 1, corresponds to the coefficient from panel A, column 4, of table 7; the coefficient in panel B, column 1, corresponds to the coefficient from panel A, column 4, of table 8; the coefficient in panel C, column 1, corresponds to the coefficient from column 5 of table 10.

Table 13.
The Marriage Market Channel

Dependent variable:	Female Labor Participation (FLP)					
	A. Baseline		B. Trends		C. IV	
	(1)	(2)	(3)	(4)	(5)	(6)
Death rate × post	0.35***	0.22***	0.40***	0.32*	0.54***	0.41***
	[0.07]	[0.07]	[0.15]	[0.16]	[0.13]	[0.14]
Share single 20-29		0.24***		0.30***		0.19***
		[0.06]		[0.11]		[0.07]
Share widows 30-49		0.55***		0.01		0.40**
		[0.21]		[0.18]		[0.20]
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
Département × Year	No	No	Yes	Yes	No	No
Observations	522	522	522	522	522	522
Départements	87	87	87	87	87	87
Within R^2	0.602	0.632	0.813	0.821	0.590	0.622
1911 FLP mean	31.4	31.4	31.4	31.4	31.4	31.4

Table 13 notes: This table reports the OLS and IV coefficients from estimating specification 10. The instruments are the class ratios. The dependent variable is female labor participation. The census years are 1901, 1911, 1921, 1926, 1931, and 1936. *Share single 20-29* is the share of women aged 20 to 29 that are single. *Share widows 30-39* is the share of women aged 30 to 49 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. See appendix M 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.

We interpret the meaning of these results in table 14 where we provide for each specification the corresponding quantities of interest $\widehat{\beta}_2 \times \widehat{\beta}_S$ and $\widehat{\beta}_3 \times \widehat{\beta}_W$, as well as the share of the total effect of military fatalities on female labor that the marriage market channel can explain. Conditional on the assumptions imposed on the data, the baseline results imply that in départements that suffered a military death rate of 20% rather than 10%, female labor participation was 0.65 percentage point higher because of women aged 20 to 29 not marrying because of the war ($10 \times 0.27 \times 0.24 \simeq 0.65$), and 0.67 percentage point higher because of women aged 30 to 49 who lost their husband because of the war ($10 \times 0.12 \times 0.55 \simeq 0.67$).

These two channels explain together about 38% of the effect of military fatalities on female labor participation.

Table 14.
Interpreting the Results in Table 13

		Baseline	Trends	IV
Share single 20-29	$\widehat{\beta}_2 \times \widehat{\beta}_S$	0.07	0.08	0.07
Share widows 30-39	$\widehat{\beta}_3 \times \widehat{\beta}_W$	0.07	0.00	0.06
Share of total effect		37%	20%	24%

Table 14 notes: The coefficients are calculated using tables 12 and 13. For instance, in column 1, $\widehat{\beta}_2 \times \widehat{\beta}_S = 0.27 \times 0.24 \simeq 0.065$, $\widehat{\beta}_3 \times \widehat{\beta}_W = 0.12 \times 0.55 \simeq 0.067$ and $1 - (0.22/0.35) \simeq 0.37$.

B. Demand Factors: Male Scarcity and Substitution Toward Female Labor

The scarcity of men in the interwar period could have induced firms to increase their demand for female labor as an input factor to substitute male labor. In a partial equilibrium framework, an increase in real wage could uncover this phenomenon. However, we documented that women increased their labor supply after the war. As a result, there is little we can say about changes in labor demand by examining changes in wage rates. On the one hand, should we find that départements that suffered higher death rates also experienced a rise in the real wage of women, then we would conclude that the increase in labor demand was strong enough to overcompensate the depressing effect of rising female labor supply on wages. On the other hand, should we find that the real wage of women decreased, we would only be able to conclude the potential increase in labor demand was not large enough to compensate the effect of increased labor supply on wages.

To assess the possibility of substitution toward female labor, we collected data on male and female daily wage rates at the département level between 1896 and 1924. The set of occupations for which we collected wage information is the same throughout, so that the skill contents of these jobs are constant. We also collected a series of prices at the département level to compute real wages. We further explore alternative channels of substitution: foreign labor, as measured by the labor force participation of foreigners, and physical capital, as measured by the number of boilers, machines, and total horse power (in thousands of kW) in a département's firms between 1908 and 1926.[57]

[57] See appendix M for a description of the sources of these data.

We estimate equation 2 where instead of female labor participation, the outcome is either female real wage, male real wage, or the ratio of male to female real wage. We report the results in table 15. We find that female real wages slightly decreased in départements that suffered relatively more military fatalities (column 1). It is unclear whether military fatalities had an impact on male wages (column 2). Overall, male wages seem to have increased relative to female wages in départements that suffered relatively more military fatalities, although this relationship is not significant at conventional levels (column 3). This suggests that if there was an increase in female labor demand in départements that experienced a higher male scarcity after the war, this increase was small and did not compensate the depressing effect of rising female labor supply on wages. These findings are consistent with the interpretation that firms did not replace male labor with alternative forms of labor such as female or foreign labor (column 4).[58] Instead, it seems that in départements that suffered more from military fatalities, firms substituted toward physical capital (columns 5 and 6). The results in column 7 suggest that the efficiency of this new physical capital did not improve.

C. Alternative Mechanisms

In this section, we examine whether the war affected female labor participation through alternative channels related to the entrance of women into the labor force *during* the war. This could have affected subsequent female labor participation through two mechanisms. First, women who entered the labor force during the war could have increased their level of human capital, or updated their beliefs about the labor market, which could have in turn increased female labor participation after the war. A similar phenomenon has been widely documented in the case of the post-WWII period in the U.S.[59] Another possibility is that men's beliefs about women's abilities to work changed because women successfully took on typically male responsibilities during the war, thereby increasing the demand for female labor. We explore these potential mechanisms, and show that neither is correlated with military fatalities. Further, neither mechanism triggered any change in female labor participation during the interwar period.

[58] There was a substantial inflow of foreign workers in post-war France: while there were about 1.1 million foreigners in France in 1911, there was about 1.5 million of them in 1921, and up to 2.5 million in 1936. This corresponds to an inflow of at most 750 thousand workers in post-war France. The location of these immigrants was not correlated with the distribution of military death rates as shown in table 15. Moreover, the process of foreign immigration counteracting labor shortage in the countryside resulting from the rural exodus had started long before WWI, in the mid-nineteenth century. As a result, "it [was] not the war that created [the shortage of men in the countryside], as many historians generally assert" (Noiriel 1994, p. 20).

[59] See Goldin (1991), Acemoglu et al. (2004), Goldin and Olivetti (2013), Doepke et al. (2015), and Cook-Stuntz (2015).

Table 15.
The Substitution Channel

Dependent variable:	Panel A. 1896-1924			Panel B. 1905-1926			
	Female wage	Male wage	Ratio M/F	Foreign labor	Boilers	Machines	Horse power
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Death rate × post	-0.04*	-0.00	0.03	-0.11	25.55*	37.49***	-0.00
	[0.02]	[0.02]	[0.02]	[0.22]	[13.85]	[12.33]	[0.01]
Rural	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Born in dép.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Département FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	520	520	522	261	261	261	261
Départements	87	87	87	87	87	87	87
Within R^2	0.329	0.519	0.022	0.468	0.083	0.189	0.195
1911 mean (levels)	2.27	4.76	2.19	35.0	1,176	937	26.55

Table 15 notes: This table reports the OLS coefficients from estimating specification 2. The dependent variable is real female daily wage in Francs (base 1911) in column 1, real male daily wage in Francs (base 1911) in column 2, the ratio of male to female real daily wage in column 3, the labor participation rate of foreigners in percents column 4, the number of boilers per department in column 5, the number of machines per département in column 6, and the log total horse power per département in thousands of kW in column 7. The survey years for columns 1-3 are 1896, 1901, 1906, 1911, and 1921. The survey years for columns 4-7 are 1908, 1911, 1921, and 1926. *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 M 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.

Female Labor During the War. The increase in female labor *during* the war could have affected female labor *after* the war. The war period in France can broadly 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 were convinced that the war would be short: since the middle of the nineteenth century, it was believed that the successful military strategies had to conduct an extremely strong initial offensive that would destroy the opponent in 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 9 where we show the evolution of the number of operating firms along with male and female employment levels in the industrial sector throughout the war. To make the evolution of these three variables more apparent, we standardize their levels to 100 just before the war. Compared to July 1914, only 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.

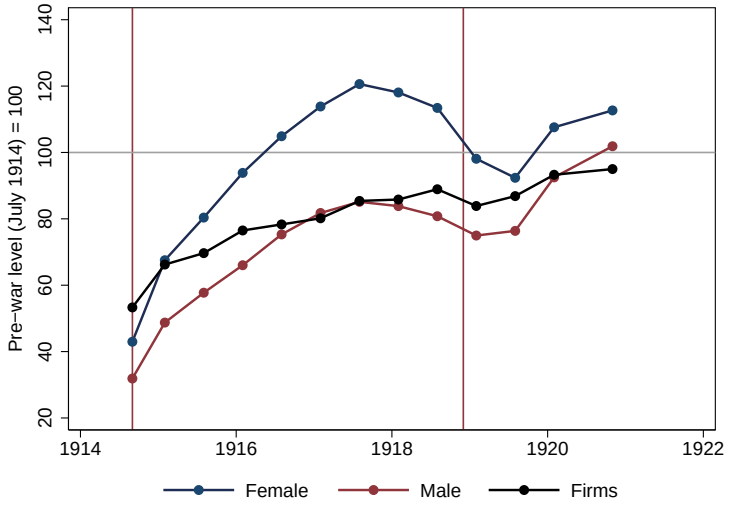


Figure 9. Labor *During* WWI (August 1914 - October 1920)

Figure 9 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 the pre-war level for all outcomes to 100 in July 1914. See appendix M for details about variable sources and definitions.

By the end of August 1914, the first month of the war, the French army had already lost about 200,000, men amounting to 15% of total military fatalities. The military command soon realized that the war would last longer than expected, and that its industrial plan to support the ongoing war effort was highly insufficient. For instance, while it had planned to produce about 13,000 shells per day at the beginning of the war, the troops were using 150,000 shells per day in combat by January 1915 (Porte 2005, pp. 66-67). To manage the extended needs of the army, the military command centralized all the industrial effort to supply the troops under the State Secretariat of Artillery and Ammunitions from November 1915, and started to coordinate a vast network of public and private industrial firms.[60]

[60]This Secretary was created by the Order of November 3rd, 1915—see the *Journal Officiel de la République*

Moreover, the government incentivized firms to employ alternative forms of labor such as women, immigrants, and war prisoners.[61] 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. Appendix table A.15 provides a comprehensive view of the evolution of the number of working women in various industrial sectors throughout the war. 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 worth of pay to any woman who would quit her job in war industries.[62] 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 mainly because of the reconstruction effort in the territories that were directly damaged by the war.

These changes in female labor during the war were uncorrelated with military death rates. In particular, we show in panel A of appendix table A.16 that the départements that experienced the highest spikes in female labor during the war did not suffer systematically more nor less military fatalities. Nevertheless, it is worth asking whether women who entered the labor force during the war to work in war industries kept working after the war. If this were the case, we should see a positive relationship between the spike in female labor during the war and changes in female labor before and after the war. To measure the local spikes in female labor, we use the level of female employment in the industrial sector in July 1917 relative to July 1914, as it was the time in which female labor was the highest—see figure 9.[63] In appendix figure B.9, we show the relative trends in female labor in places that experienced a high and a low increase in female labor during the war. Départements that experienced a higher increase in female labor during the war did not experience any post-war increase in female labor. We find the same results when estimating difference-in-difference regressions:

Française, Lois et Décrets, *47* (306), pp. 8108-8109, dated November 11th, 1915.

[61] *Ciruclaire* of the Ministère de la Guerre of November 10th, 1915—see the *Journal Officiel de la République Française, Lois et Décrets*, *47* (306), p. 8110, dated November 11th, 1915.

[62] 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*).

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

in columns 1 and 2 of panel A of appendix table A.17, we show that changes in female labor during the war were not correlated with any post-war increase in female labor.

These findings are consistent with historical accounts of labor inspectors from that time, 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 extreme division of labor, women could hardly acquire human capital transferable to other sectors after the war.

Changes in Men's Beliefs about Gender Roles. The war could have increased female labor in the post-war period by changing men's beliefs about gender roles. For instance, men could have updated their beliefs about women's abilities because of women's positive role during the war in industries or in farming. To measure how men's beliefs about gender roles changed before and after the war, we use deputés' support to the extension of the suffrage to women. We build on the fact that the extension of the suffrage to women was discussed before and after the war in the Assemblée Nationale. Women did not have the right to vote prior 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 at the Assemblée Nationale.[64] This phenomenon is not specific to France: Hicks (2013) finds that wars in the twentieth century doubled the likelihood for 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.[65] The data for the vote on the extension of female suffrage in May 1919 are from the reports of the debates in the Assemblée Nationale.[66] We then constructed an average support for female suffrage at the département level before and after the war by aggregating supports and vote

[64]This bill eventually did not become a law because it was rejected by the Sénat, France's upper house, in 1923. Bouglé-Moalic (2012) provides a historical account of the extension of female suffrage in France.

[65]A copy of this letter is available in appendix N.

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

choices of députés from each département. Appendix table A.18 reports these measures together with the data at the individual député level. While only 30% of députés supported female suffrage before the war, about 80% did so after the war.

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 abilities as voters. To alleviate the later 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 were more Catholic tended to adopt female suffrage later in the course of their 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.[67] 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. Our findings suggest that the support to the extension of the suffrage to women is a reasonable measure for local conservatism toward gender roles.

Changes in the support to the extension of the suffrage to women are uncorrelated with military death rates: départements in which députés switched their support for female suffrage did not suffer systematically more nor less military fatalities—see panel B of appendix table A.16. Moreover, plotting the trends in female labor across varying changes in support reveals no relationship—see appendix figure B.10. This is confirmed by the results from difference-in-differences regressions—see columns 3 and 4 of panel A of appendix table A.17.

VI. Conclusion

We construct a unique dataset of military fatalities and département characteristics, and show that the shortage of men induced by WWI increased female labor participation. In particular, départements with military death rates of 20% rather than 10% experienced an increase in female labor participation of about 12% compared to pre-war levels. This effect

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

is stable throughout the interwar period, and robust to alternative empirical strategies. Our findings show that the effect is generated by changes in labor supply. In particular, many young single women as well as war widows entered the labor force. Neither changes in labor demand, nor female labor during the war, nor changes in men's views about gender roles can explain the patterns we observe in the data.

A broad literature has analyzed the impact of war mobilization and war casualties on female labor participation. It has mostly focused on the impact of WWII mobilization in the U.S. In general, this literature finds that war mobilization during WWII increased female labor supply in the 1950s and 1960s (Goldin 1991, Acemoglu et al. 2004, Goldin and Olivetti 2013). In comparison, the magnitude of military fatalities in France during WWI enables us to focus on the impact of permanent rather than temporary imbalances in sex ratio. Moreover, we find no decline of the effect throughout the interwar period, and no evidence that women who entered the labor force *during* the war kept working *after* the war. Overall, our findings challenge both the popular belief that the war "liberated" women, and the consensus among historians that it was a mere "parenthesis" for female labor (see footnote 7 on page 7): instead, the *missing men* set off a mechanism that induced women to enter low-skilled domestic services and industrial jobs after the war.

This paper evaluates the effects of gender imbalances on female labor participation by analyzing one particular historic event. More broadly, war, sex-selective abortion, and mass migration have altered gender balances throughout the world and throughout history. Our results may help to understand the consequences of such imbalances to labor markets.

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