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Women's Education and Fertility in Italy at the Onset of the Demographic Transition

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Abstract

The role of women's education in driving the historical fertility transition remains poorly understood. Existing studies have focused on France, an early outlier, or on Prussia before the onset of its demographic transition. Less is known about the context where this effect is expected to be strongest: the onset of the transition in late-transitioning countries. This paper fills this gap by studying the impact of women's education on fertility in Italy (1881-1921). Using original district-level panel data, we exploit the interaction between proximity to the first female teacher-training colleges opened under the Casati Law of 1859 and time fixed effects as an instrumental variable. IV estimates confirm a negative effect of education on fertility, operating through health knowledge and the economic independence that female teachers embodied.

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1 Introduction

The decline in fertility accompanying the transition to modern economic growth represents one of the most fundamental demographic transformations in human history (Guinnane, 2011; Galor, 2012). This transformation enabled economies to channel the gains from factor accumulation and technological progress into higher income per capita (Galor, 2022). Understanding its underlying mechanisms is therefore central to explaining the emergence of modern economic growth. Within the child quantity-quality framework linking human capital accumulation and demographic change, the education of mothers plays a central but empirically understudied role: more educated women face a higher opportunity cost of childrearing, possess greater bargaining power within the household, and have better access to information about family planning (Cinnirella, 2019). Despite this theoretical relevance, causal evidence on women's education and fertility during the historical demographic transition remains scarce. Existing studies have concentrated either on France, a remarkable outlier whose fertility decline preceded the rest of Europe by several decades, or on Prussia before its transition had begun, leaving the onset of the demographic transition in late-transitioning countries largely unexplored. This gap is consequential, since, as stressed by Livi Bacci when discussing women's reproductive behaviour, "[women's] education may play a very important role in determining the level of fertility at the beginning of the process of fertility decline because it facilitates the diffusion of birth-control knowledge; but education may be irrelevant when fertility has already reached a moderate level" (Livi Bacci, 1977, p. 190).

This paper addresses these gaps by studying the effect of women's education on fertility in Italy at the onset of the Italian demographic transition (1881-1921). This country offers a uniquely compelling setting for this investigation. First, late nineteenth-century Italy was characterised by an exceptionally pronounced territorial divide in both female literacy and fertility. Indeed, it was one of the sharpest in Europe at the time (Cipolla, 1969; Coale and Watkins, 1986). Moreover, Italy started its demographic transition later than many Western European countries, due to persistently high mortality and its particular vulnerability to economic fluctuations and epidemics until the 1870s, which sustained high fertility through precautionary behaviour (Livi Bacci and Breschi, 1990). Crucially, just as female literacy and fertility varied sharply across regions, so too did infant and child mortality. Studies on Italian provinces document dramatic territorial differentials in infant death rates well into the early twentieth century (e.g., Pozzi, 2001), reinforcing the picture of a deeply heterogeneous country in which the demographic transition unfolded unevenly across space. The above features generate rich internal variation for identification purposes and, given our focus on the initial stage of the transition, make Italy an ideal setting for testing both the predictions of unified growth theory and the female empowerment hypothesis.

To estimate the impact of female education on fertility, we collect new historical panel data at the district level on education, fertility, and a rich set of socioeconomic variables.[1] We find that, conditional on numerous fertility demand and supply factors, as well as on fixed effects of districts and years, a one-standard-deviation increase in mothers' literacy rate predicts a reduction in fertility of 0.37 standard deviations. To limit endogeneity concerns, we implement a novel instrumental-variables strategy that exploits exogenous variation in female education arising from the establishment of the first teacher-training institutes for women, known as female normal schools (*scuole normali femminili*), as mandated by the Casati Law of 1859, the foundational legislation on elementary education in Italy. Our approach exploits the interaction between the geographic distance from these schools and time fixed effects as an instrumental variable, introducing a plausibly exogenous source of identification to estimate the causal effect of maternal schooling on fertility. Since the distance from the first female normal schools is time-invariant, it is absorbed by district fixed effects and thus cannot directly confound our estimates, a feature that substantially mitigates concerns about the endogeneity of school placement. The instrument validity is also supported by a range of balance tests showing no significant relationship between proximity to these schools and predetermined characteristics. Our IV findings confirm the negative effect estimated via OLS. Among several robustness checks, our results persist if we use an alternative fertility proxy and account for the demographic consequences of World War I.

As proximate mechanisms, we show that the primary channel through which education affected fertility was women's economic independence, embodied in the growing role of female schoolteachers as role models for unmarried, childless, and economically autonomous womanhood. We also find evidence that a secondary mechanism was at play in the Italian setting: in a context of persistent child mortality, maternal education reduced precautionary fertility by improving knowledge of disease prevention and the ability to process health information, thus lowering infant mortality.

1.1 Contribution

By investigating the effect of female education on fertility at the first stage of the demographic transition in a late-transitioning country such as Italy, and also assembling a new district-level

[1] Districts were intermediate administrative units between municipalities and provinces. To put things in perspective, in 1911 Italy had a population of about 35 million and its territory included 69 provinces, 284 districts, and more than 8,000 municipalities.

historical panel dataset on education, fertility, and several socio-economic characteristics, we contribute to several strands of literature.

First, our paper is related to the literature on the child quantity-quality trade-off and unified growth theory (e.g., Becker, 1960; Becker and Lewis, 1973; Galor and Weil, 2000; Galor, 2011; 2022; Murphy, 2015; Klemp and Weisdorf, 2019).[2] Within this framework, a strand of empirical research investigates the relationship between *children's education* and fertility during the historical transition in Western Europe (see Cinnirella, 2019, for a detailed review of this literature). Becker et al. (2010; 2012) document a negative relationship in Prussia. Diebolt et al. (2017) find instead no causal effect in mid-nineteenth-century France, when the transition was already partly completed. Fernihough (2017) provides additional support for the child quantity-quality trade-off in Ireland. More directly related to this paper, the role of parental education, especially maternal, has received relatively less attention, despite its theoretical centrality. Crucially, existing causal evidence focuses either on Prussia in its pre-transition period or on France after the transition was already underway (Diebolt and Perrin, 2013; de la Croix and Perrin, 2018). In the Prussian case, in particular, Becker et al. (2013) find a robust negative relationship between *women's education* and fertility using panel fixed effects and IV estimation based on variation in landownership concentration. As a result, the impact of mothers' education on fertility at the onset of the demographic transition in late-transitioning countries, such as Italy, remains largely unexplored. Importantly, as Livi Bacci (1977) argues, this is precisely the context in which the effect of education on fertility is expected to be strongest.

This paper is also connected to the literature emphasising the role of female empowerment more broadly. Education can affect women's social status, employment opportunities, and decision-making power within the household and society, thereby contributing to a decline in fertility (Goldin, 1990; de la Croix and Vander Donckt, 2010; Diebolt and Perrin, 2013; Jayachandran and Voena, 2025). Diebolt and Perrin (2013), in particular, provide long-run descriptive evidence for France and argues that female empowerment through education raised the opportunity cost of fertility and encouraged greater investment in offspring, contributing to the shift toward low fertility regimes. Our results are consistent with this interpretation, which we identify as the primary underlying mechanism. Specifically, we document a role model effect embodied by female schoolteachers active in Italy at the turn of

[2] A complementary approach to the study of the fertility transition draws on the insights of the European Fertility Project of the 1960s-70s, highlighting the role of culture and social norms in shaping fertility decisions (Coale, 1973; Coale and Watkins, 1986). This strand of research aims to provide causal evidence on the historical fertility transition in various advanced economies since the late eighteenth century (e.g., Spolaore and Wacziarg, 2022; Beach and Hanlon, 2023; Blanc, 2024).

the twentieth century: an increasing number of young educated women entered the teaching profession to achieve economic autonomy, often rejecting marriage and motherhood, while simultaneously exerting a broader influence on the female population around them. We further show that the negative effect of education on fertility is likely mediated also by improvements in child survival, as more educated mothers had better access to information about health and family planning (Crafts, 1984; Boyer and Williamson, 1989; Basu, 2002), suggesting that multiple mechanisms may operate simultaneously.

Our identification strategy, based on the geographic distance from the first female normal schools established under the Casati Law of 1859, also speaks to a growing literature exploiting geographic variation in access to educational institutions as a source of exogenous identification. Seminal contributions include Card (1993) on proximity to colleges in the post-war United States, Currie and Moretti (2003) on college openings and maternal education, Cantoni and Yuchtman (2014) on medieval university foundations in Germany, and Valero and Van Reenen (2019) on the relationship between universities and GDP growth. Building on this literature, we exploit proximity to normal schools as an exogenous source of variation in local exposure to qualified teachers and access to primary education.

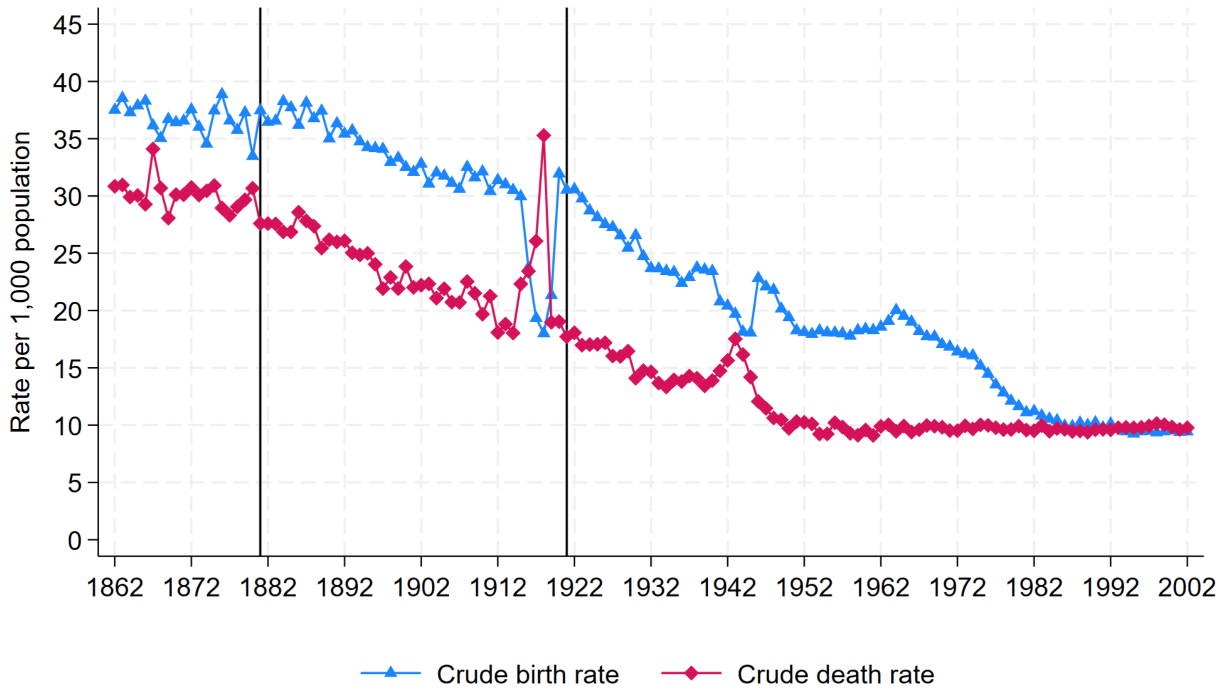
Our paper also contributes to the literature on Italy's economic and demographic history. Italian historical demographers generally agree that the effect of education on fertility is time-specific, tending to be stronger at the early stages of the demographic transition and weaker at later stages (Livi Bacci, 1977; Breschi et al., 2013). Within this line of inquiry, Caltabiano and Dalla Zuanna (2015*a*) provide descriptive evidence of a negative fertility gradient by education at the national level during the period of our interest, while Breschi et al. (2013) and Breschi et al. (2016) document a negative relationship between educational attainment and completed family size using micro-level data from selected town populations across Italy. However, these studies lack the broad geographical coverage offered in this paper, do not exploit exogenous variation in women's education, and do not explore the mechanisms we propose.

The remainder of this paper is organized as follows. Section 2 provides some historical background. Section 3 describes the data and empirical methodology. Section 4 presents the main results. Section 5 explores the underlying mechanisms. Finally, Section 6 concludes.

2 Historical Background

This section reviews Italy's demographic transition and the historical development of female primary education, highlighting the substantial geographic heterogeneity of both. This heterogeneity, combined with the geographic placement of the first teacher-training colleges

Figure 1: The Demographic Transition in Italy, 1861-2002



Notes: Annual crude birth rate and crude mortality rate in Italy in the period 1862-2001. The former represents the ratio of total live births to the average resident population (in thousands) in a given year. The latter is the ratio of total deaths to the average resident population (in thousands) in a given year. The vertical lines indicate the years 1881 and 1921, which delimit the sample period of the present study. *Source*: ISTAT *Serie Storiche, Popolazione*, Table 2.3 (link: `https://seriestoriche.istat.it/`, last access: April 2026).

(normal schools) in a limited number of localities across the newly unified kingdom, provides, as we argue below, the identifying variation exploited in our instrumental-variables strategy.

2.1 The Demographic Transition in Italy

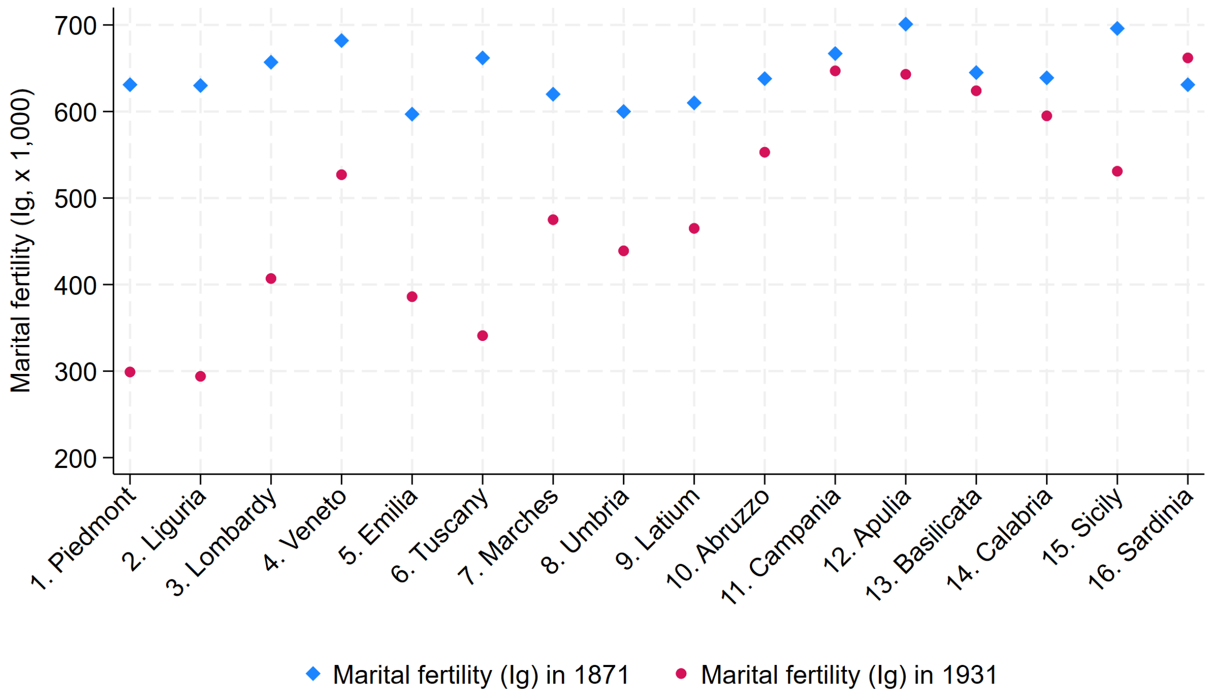
The Italian demographic transition, i.e., the shift from a regime of high birth and death rates (above 30 per thousand) to one of low birth and death rates (around ten per thousand), occurred approximately in the century between 1880 and 1980 (see Figure 1). This process has been widely analysed by Italian historical demographers and economic historians (Livi Bacci, 1977; Bellettini, 1981; Del Panta, 1984; Vecchi, 2017). The literature has emphasised, in particular, the role played by factors such as nutrition (Livi Bacci, 1986; Federico, 2003), sanitation, hygiene and vaccination (Pozzi, 2001; Fiore Melacrinis and Rota, 2025), as well as the reduction in the occurrence of plagues and pandemics (Del Panta, 2021).

There is general agreement that the timing of the transition was regionally stratified, with the northern regions acting as forerunners, and the southern regions entering the transition only around the turn of the twentieth century (Livi Bacci and Breschi, 1990; Breschi et al., 1994). Figure 2 illustrates the regional pattern of marital fertility across Italian regions in 1871 and 1931. The regions are ordered geographically along the x-axis, with the northern regions (numbered from 1 to 4) on the left, followed by the central regions (numbered from 5 to 9), and the southern regions (numbered from 10 to 16) on the right. In 1871, no clear regional pattern was apparent, although the highest fertility levels were mostly in the South (Apulia and Sicily). Following the onset of the demographic transition, a distinct regional gradient was evident in 1931: northern regions experienced a sharp decline in fertility, whereas the decrease remained moderate in the southern regions.[3]

In addition to the regional disparities just highlighted, Livi Bacci (1977)—whose estimates for Italy form part of the Princeton European Fertility Project—emphasises the importance of using territorially disaggregated fertility data at the sub-regional, and even sub-provincial, level, given the considerable spatial heterogeneity characterising the Italian case. Livi Bacci presents pioneering fertility estimates for Italian districts and provinces for selected benchmark years in the late nineteenth and early twentieth centuries, and contrasts them across these spatial units. Even a quick comparison of the maps including fertility estimates there presented, as we will confirm in the data section of this paper, shows that the level of disaggregation matters. The most evident case is perhaps provided by the regions of Latium, Umbria, and Basilicata, which, in the historical sources of the time (such as population censuses and civil registers), included only one province. In these cases, regional and provincial estimates coincide by definition, and only an analysis at the sub-provincial level can adequately capture the substantial heterogeneity within such administrative units. We return to this point in Section 3.2, where the value of analysing the onset of the Italian fertility transition with district-level data becomes evident.

[3] The macro-regions of northern and southern Italy were, of course, not entirely homogeneous. For example, within the North, the Veneto region in northeastern Italy experienced the onset of the demographic transition later than Piedmont, Liguria, and Lombardy (Livi Bacci, 1986; Caltabiano and Dalla Zuanna, 2015*b*). Also, as already noted in Livi Bacci and Breschi (1990), historical data on marital fertility should be interpreted with caution as far as migration is concerned, and especially so during the Age of Mass Migration, when Italy was an important migrant-sending country. As a result, in several regions marital fertility was depressed by the prolonged absence of men, who contributed substantially to migration outflows. It is also possible that the estimates for 1871 for the regions of the former Papal States (including Emilia, Marches, Umbria, and Latium) illustrated in Figure 2 underestimate marital fertility. In these regions, as discussed in Livi Bacci and Breschi (1990), secularization progressed slowly, and the public marriage registers of the newly established state failed to record marriages of couples who registered their unions only with the Church, as had been customary in the years and decades prior to the Italian unification.

Figure 2: The Onset of the Fertility Transition in Italian Regions, 1871 and 1931



Notes: Marital fertility index across Italian regions in 1871 and 1931, defined as follows: $I_g = \frac{\sum g_j m_j}{\sum F_j m_j}$, where j denotes a given age cohort, g_j is the number of births per married woman in age cohort j, m_j is the number of married women in age cohort j, and F_j is the number of births per woman in age cohort j from the high-fertility reference population (i.e., married Hutterite women in the period 1921-1930). See Livi Bacci (1977), p. 56, for further details. Northern regions are numbered from 1 to 4, central regions are numbered from 5 to 9, and southern regions are numbered from 10 to 16. *Source*: Authors' elaborations on data reported in Livi Bacci (1977).

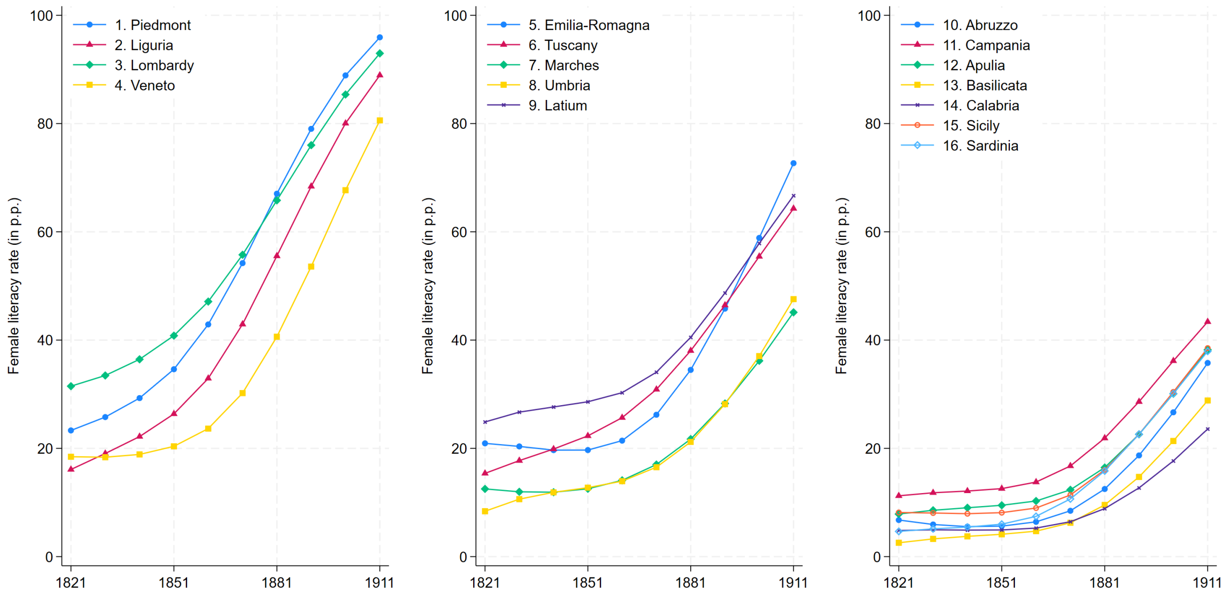
2.2 Women's Education in Post-Unification Italy

In the aftermath of its unification (1861), Italy exhibited extremely high levels of population illiteracy. Coeval official statistics reported that only about 32 percent of men and 19 percent of women aged five and above were able at least to read.[4] Only Spain, Portugal, and the Russian Empire recorded lower literacy rates in Europe (Cipolla, 1969). These national figures, however, conceal considerable geographical heterogeneity. In 1861, North-Western Italy recorded proportions of literate men and women that were higher, respectively, by 33 and 31 percentage points than those observed in the southern regions (Vigo, 1993, p. 51).

Given our focus on women's education, we now examine the territorial gap in female education from a broader temporal perspective. Figure 3 shows the evolution of regional

[4] See the 1861 population census (cf. volume 2, p. XXII).

Figure 3: Regional Trends in Women's Literacy Rates, 1821-1911



(A) Northern Italy. (B) Central Italy. (C) Southern Italy.

Notes: Annual literacy rate of women aged 30-40 across Italian regions at ten-year intervals. The sixteen regions shown are the same included in Figure 2. *Source*: Authors' elaborations on data from Ciccarelli and Weisdorf (2019).

differences in literacy rates among women aged 30-40 across Italian regions from 1821 to 1911, at ten-year intervals.[5] Two facts clearly emerge from this figure. First, the divide in female literacy across Italian macro-areas was already evident in the early nineteenth century, with northern regions leading the way. Second, different trajectories can be observed across macro-areas. In the North and partly in the Center, literacy rates had already begun to increase before 1861, whereas the South exhibited a classic hockey-stick pattern, with little or no improvement in literacy prior to unification, and substantial gains thereafter. Nevertheless, the late increases in female literacy recorded in southern regions were smaller than those achieved in the territories north of Rome. Even after the turn of the twentieth century, less than fifty percent of southern women were able to read and write.

While regional trends, such as those reported in Figure 3, and provincial estimates, such as those in Ciccarelli and Weisdorf (2019), offer valuable information, they may also hide

[5]We report descriptive evidence for the 30-40 age group only, as this cohort is expected to capture completed schooling (Ciccarelli and Weisdorf, 2019), while also limiting cohort bias arising from differential exposure to late schooling reforms.

substantial disparities in literacy rates within provinces, as already noted in the earlier analysis of fertility. According to the pioneering analysis of the school system conducted by Ester De Fort, based on district-level data, literacy conditions in 1911 differed markedly between provincial capital cities and the rest of the provinces across Italy (De Fort, 1995, p. 50). National averages, computed across all provinces, indicate that the illiteracy rate of the population aged six and above was about 23 percent in provincial capital cities, compared with roughly 41 percent in the rest of the provinces. Overall, these differences were more pronounced in southern regions than in northern ones. In Piedmont, for example, the comparison between the illiteracy rate in the provincial capital cities (about 7 percent) and in the rest of the provinces (12 percent) shows relatively limited disparities. By contrast, in Sicily the comparison reveals much sharper differences: illiteracy amounted to about 41 percent in provincial capital cities, compared with 63 percent in the territories surrounding these municipalities.[6]

The Casati Law and the normal schools. As described in Cappelli and Quiroga Valle (2021), the upward trend in female literacy rates in post-unification Italy just described went hand in hand with changes in the composition of the primary-school teaching workforce. In particular, the share of female teachers increased steadily from 1861 until the interwar period. This growing feminization of primary schooling was partly the result of a set of institutional rules introduced in the first national school legislation of unified Italy, namely the Casati Law (1859). This legislation was originally enacted in 1859 to organize the education system of the Kingdom of Sardinia, which comprised the regions of Piedmont, Liguria, and Sardinia, just months after the annexation of Lombardy.[7] It was subsequently extended to the newly unified Italian kingdom in 1861, as the country was still undergoing the unification process.[8]

The Casati Law organized education from kindergarten to university and established national rules governing both the content of schooling and the salary of teachers (Vigo, 1971; Cappelli and Quiroga Valle, 2021). The law stipulated that primary education had to be offered free of charge, in proportion to municipalities' spending capacity and according to residents' needs. The primary school system was organized over four years, divided into two cycles (lower and upper) of two years each. The lower cycle was made compulsory for

[6]Basile et al. (2022) proposes a systematic analysis of disparities in literacy rates between provincial capital cities and the entire provinces in the Kingdom of Italy during the period 1871-1911. Their analysis shows that only in the North did the territorial gap between provincial centres and peripheries narrow, while in the South the gap remained substantial even on the eve of World War I.

[7]See the map reported in Figure B4 of the Appendix.

[8]The original text of the main articles of this school act and the respective translations are both available in Section A3 in Online Appendix A.

all pupils between the ages of six and eight, while the upper cycle was mandatory only for children living in larger municipalities or in places where a secondary school had already been set up. Each municipality was also required to establish two single-sex primary schools, one for boys and one for girls. However, the responsibility for providing primary education rested with the municipalities, which in many cases lacked the necessary financial resources to pay teachers' salaries (A'Hearn, 2017). To address the large regional inequalities in educational investments and, above all, the widespread lack of compliance with compulsory education, the Coppino Reform (1877) extended compulsory primary schooling from two to three years, introduced (modest) sanctions for non-enrolment, and allowed limited state subsidies for building schoolhouses and supplying teaching materials. More incisive efforts to improve the primary school system were undertaken at the beginning of the twentieth century: female teachers' salaries were substantially increased in 1903 (Nasi Law), the compulsory schooling age was raised to twelve in 1904 (Orlando Law), and school management and funding were ultimately centralized in 1911 with the Daneo-Credaro Reform (A'Hearn et al., 2011).[9]

Regarding the teaching staff of primary schools, the Casati Law established single-sex teacher-training institutes known as *normal schools*. Training in these institutions lasted three years, and aspiring teachers could enrol after the age of fifteen (if female) or sixteen (if male), conditional on passing the required entry examination. Unlike schoolteachers' salaries, professors' salaries in normal schools were paid by the central government, whereas the provision of the remaining services (including buildings and furnishings) was entrusted to the municipalities using their own funds.

The Casati Law initially mandated the creation of eighteen normal schools, nine for men and nine for women, all located in a limited number of north-western regions (plus Sardinia). Although the law does not offer precise information on the geographical distribution of the first normal schools (article 357, see Section A3 in Online Appendix A), we recover the exact location of these schools from royal decrees issued to implement the law upon the proposal of the Italian Minister of Public Education, who also indicated their location. The first female normal schools of the Kingdom of Italy were established in eight municipalities: Alessandria, Brescia, Cagliari, Como, Genoa, Milan, Mondovì, and Vercelli (see Figure 4). The first male normal schools were instead set up in the municipalities of Casale Monferrato, Crema, Lodi, Novara, Oneglia, Pinerolo, Sassari, and Treviglio (see Figure B2, Online Appendix B). As noted above, the law called for the opening of eighteen institutes, but only the sixteen schools listed above ultimately came under Italian jurisdiction. The planned female and male normal

[9] In particular, the Daneo-Credaro Reform of 1911 has been found to generate positive effects on literacy rates in affected municipalities of the time (Cappelli and Vasta, 2020; 2021).

schools in the Savoy region were instead opened, respectively, in Rumilly and Albertville by the French authorities following the Treaty of Turin (March 24, 1860), through which Italy ceded Savoy to France after an eight-month negotiation. The fact that two normal schools had already been assigned to a territory whose sovereignty was still being negotiated suggests that the geographic placement of these educational institutions was likely to reflect the bureaucratic logic of a state whose borders had not yet been finalised. Moreover, apart from Milan and Genoa exhibiting populations between 100,000 and 200,000 inhabitants in 1861, the remaining municipalities hosting the initial normal schools were small or medium-sized towns, none of which figures prominently in the historical literature as an economically or demographically significant hub. This further suggests that the geographic placement of these schools was not primarily driven by educational, economic, or demographic criteria. Finally, a reader familiar with Italian economic geography might be tempted to interpret the concentration of normal schools in Piedmont, Liguria, and Lombardy as reflecting the economic dynamism of what would later become Italy's industrial triangle, centred around Milan, Turin, and Genoa. This interpretation, however, would be anachronistic. It is well established that Italian industrialisation, including in the north-western regions, occurred several decades after the enactment of the Casati Law in 1859 (Fenoaltea, 2011). The geographic distribution of the first normal schools therefore appears to have been shaped by considerations other than economic or demographic ones.

The initial normal schools soon proved insufficient to address the severe shortage of qualified instructors in primary schools following Italy's unification. Consequently, a few years later the central government established additional normal schools throughout the country via royal decrees. The total number of teacher-training institutes then expanded over decades until reaching 130 by 1916 (Covato and Sorge, 1994, pp. 26-27). Importantly, as female normal schools increasingly found young women's favour, they began to outnumber male normal schools, contributing to the progressive feminization of the teaching profession in Italy.[10]

Although the geographical distribution of normal schools across the country appeared relatively well-spread a few decades after 1861, the stronger exposure to the first teacher-training institutes likely gave territories in the North-West a persistent advantage in literacy over more distant regions, via a relatively higher supply of teachers. This mechanism

[10] By the end of the nineteenth century, the feminization of the teaching profession was already profound, with women heavily outnumbering men both as students in normal schools (19,864 compared to just 1,323 in 1900) and as teachers in public elementary schools (44,561 compared to 21,178 in 1901) (Covato, 1996, p. 22). The shift toward a female-dominated teaching profession was not unique to late nineteenth-century Italy; it occurred during the same period in many other countries, including England, Russia, and the United States (Albisetti, 1993).

Figure 4: The First Female Normal Schools in Italy

Notes: Municipalities hosting a female normal school by the end of 1860 (red circles). Regional borders from 1921 are in bold. *Source*: Executive decrees of Casati Law (1859).

rests on the assumption that schoolteachers tended to remain in the districts where they had received their training. Consistent with this, although there were episodes of teachers moving from northern regions—where they had studied—to southern regions for extended periods (Soldani, 1993, p. 107), such mobility was actively discouraged by national authorities and never became a dominant pattern.[11]

According to the Casati Law, after graduating from normal schools, male schoolteachers were required to teach only in male primary schools, whereas this restriction did not apply

[11]See, for instance, official communications by the Italian ministers of public education Emilio Broglio in 1868 and Michele Coppino in 1878. The former heartily recommended the prefect of Bari to encourage nearby municipalities to train "teachers who would return to their own municipality" and avoid hiring female teachers from northern Italy, partly out of concern for social tensions (and also because these teachers demanded higher salaries). The latter urged rural municipalities to employ "local teachers trained locally, [...] who were not affected by improper ambitions" (Bini, 1989, pp. 344-345, and Soldani, 1993, p. 109).

to female teachers (article 324, see Section A3 in Online Appendix A). This key institutional feature of the Italian primary school system, as we will discuss more in depth in Section 3, explains why our instrumental-variables strategy relies on proximity to the first female normal schools, rather than proximity to any of the first normal schools established by the Casati Law. The law also introduced explicit gender discrimination in teachers' pay, setting minimum salaries for female teachers at one-third lower than those of their male counterparts, regardless of the location of the school. Despite these limitations, the instruction provided in normal schools—although often rather modest—prepared women for the first intellectual profession accessible to them. This was socially significant because it offered the prospect of better-paid employment compared with traditional female occupations (Cappelli and Quiroga Valle, 2021), while also providing a pathway to greater economic and social independence. Moreover, since normal schools represented essentially the only available avenue of cultural education for girls, they came to serve *de facto* a broader educational demand than originally intended. As a result, many girls enrolled without necessarily planning to pursue a teaching career. For them, the education acquired in these schools could nonetheless open access to more qualified labour opportunities (Gaballo, 2016).

The historical evidence reviewed in this section motivates both the empirical design and the identification strategy of this paper. The pronounced and persistent regional divide in female literacy and the substantial heterogeneity in fertility across districts provide the within-country variation exploited in our panel regressions, while the bureaucratic logic behind the geographic placement of the first normal schools provides the source of plausibly exogenous variation exploited in our instrumental variables strategy, as formalised in the following sections.

3 Methodology and Data

In this section we first present the empirical methodology and then introduce the actual data used for our analysis.

3.1 Methodology

To investigate the relationship between women's education and fertility, we start by estimating the following two-way fixed effects model using ordinary least squares (OLS):

$$Fertility_{it+20} = \beta_1\, Education_{it} + \beta_2{}' x_{it} + \beta_3{}' x_i \delta_t + \alpha_i + \delta_t + \eta_{it+20} \quad (1)$$

In this equation, $Fertility_{it+20}$ denotes fertility in district i in year $t + 20$, where $t \in$

$\{1881, 1901\}$. This variable accounts for the fertility choices in year $t+20$ of women who were school-age children in year t. $Education_{it}$, the main explanatory variable, represents the literacy rate of school-age women in district i in year t. β_1 is the main coefficient of interest. The terms α_i and δ_t indicate, respectively, district and year fixed effects. The former fixed effects capture unobservable time-invariant variables that may be correlated with fertility, such as cultural attitudes towards procreation at the local level. The latter fixed effects instead absorb any unobserved variable that affects all districts equally in specific years, like the introduction of a new contraception method. Finally, x_{it} and x_i are vectors of control variables accounting for demographic, geographic and socio-economic characteristics.[12] The time-invariant confounders x_i are interacted flexibly with year fixed effects. All these variables are discussed in detail in Section 3.2. We cluster standard errors at the district level to allow for arbitrary correlation of errors within districts. In robustness tables we also report Conley (1999)'s spatially-corrected standard errors to account for spatial autocorrelation with different distance cut-offs.

To further assess period-specific relationships, the panel analysis in Equation (1) is complemented with a cross-sectional model of the following form:

$$Fertility_{ipt+20} = \beta_4\, Education_{ipt} + \beta_5{}' x_{ipt} + \beta_6{}' x_{ip} + \gamma_p + \epsilon_{ipt+20}, \qquad (2)$$

that we estimate separately for each $t \in \{1881, 1901\}$. In this model each variable is observed for district i in province p and year t (or year $t+20$, in the case of the dependent variable). Here our focus is on the coefficient β_4. We use the same set of confounders x_{ipt} and x_{ip} as in Equation (1). The novel term γ_p denotes province fixed effects. In this setting, we cluster standard errors by province and implement again Conley (1999)'s standard errors for robustness.

The OLS estimated parameters $\hat{\beta}_1$ and $\hat{\beta}_4$ are unlikely to have a causal interpretation for two main reasons. Firstly, there may exist omitted time-varying confounders that correlate with both fertility and education. Secondly, reverse causality could be a concern, as fertility may itself affect how much education women obtain. To address both issues, we devise an instrumental-variables strategy that relies on plausibly exogenous variation in young women's literacy rates coming from proximity to the first female normal schools opened in the Kingdom of Italy in 1860, interacted with time binary indicators.[13] We conjecture that districts being

[12]This paper focuses solely on the effect of female education on fertility. The very high correlation between male and female school-age literacy rates, however, prevents us from econometrically disentangling the effects of women's and men's education in the regression analysis.

[13]Instrumenting for young female literacy using distance to normal schools being in place in year $t \in \{1881, 1901\}$ could potentially lead to a violation of the IV exclusion restriction, as after 1860 school locations

closer to such pioneering schools had a larger potential supply of female primary-school teachers over time than more distant districts, holding anything else constant.[14] Higher female literacy rates would consequently spring from a larger presence of female teachers in the local area.

Formally, our first-stage equation is the following:

$$Education_{it} = \beta_7 \, NormalSchool_{i1860} \times \delta_t + \beta_8{}' x_{it} + \beta_9{}' x_i \delta_t + \alpha_i + \delta_t + \mu_{it}. \qquad (3)$$

where $NormalSchool_{i1860}$ represents the time-invariant distance from the centroid of district i to the closest female normal school being active in 1860. We interact this distance with year fixed effects δ_t to allow the relationship between proximity to normal schools and early-life female education to vary in each year of the panel.[15]

3.2 Data

We build a novel panel dataset at district-year level for the years 1881, 1901 and 1921. Districts (*circondari*) were Italian administrative units whose jurisdiction and geographical extension fell between provinces and municipalities (*comuni*). We use district borders of 1921, excluding the regions of Julian Venetia and Trentino that were annexed to the Kingdom of Italy only in 1920. Our estimation sample includes 201 districts and covers almost the whole Kingdom of Italy. The only exception is represented by the north-eastern region of Veneto, for which we can retrieve systematic data for only three out of sixteen districts.[16]

Our main data sources are the population censuses of 1881, 1901 and 1921, from which we extract information on population counts, urbanization rates, literacy rates, marital status,

may have been influenced by economic and urban development and thus partly correlated with pre-existing fertility. If so, the causal chain would run from fertility to the presence of normal schools, which is precisely what we want to avoid. On the contrary, we believe that, by choosing distance to the locations hosting the first normal schools in 1860, endogeneity bias would be much less of a concern, as both economic development and urbanization were still at an early stage back then. Reassuringly, our choice is also supported by the evidence provided in Figure B1 (Online Appendix B), where we show that the geographical distribution of the first female normal schools is uncorrelated with fertility patterns around 1860 and other variables reasonably related to them.

[14] In addition to the anecdotal evidence already mentioned in Section 2.2, we corroborate this hypothesis by regressing the share of female teachers in each district in 1881, 1901 and 1921 on the distance from the earliest female normal schools in a cross-sectional fashion. The results of this empirical exercise, shown in Table B2 (Online Appendix B), suggest that, at the turn of the twentieth century, districts being closer to the first female normal schools were more likely to report a larger share of female teachers over the female population aged nine and above.

[15] We use 1881 as baseline year, so our instrumental variable is equivalent to the interaction term $NormalSchool_{i1860} \times \mathbb{1}\{t = 1901\}$.

[16] For further details about our unit of observation, we refer the reader to Section A1 in Online Appendix A.

and employment levels by economic sector and profession.[17] We combine these sources with official records on migration flows and mortality levels. We also exploit information from several sources of Geographic Information System (GIS) data.

Below we briefly describe our main variables of interest. Additional information about the definition of all variables, their unit of observation, the time period considered (from the 1830s to 1921), and the data sources employed to compute them, can be found in Table A1 (Online Appendix A). Summary statistics for all variables are also reported in Table B1 (Online Appendix B).

Education. The 1881 and 1901 censuses report district-level literacy by gender and age. However, they rely on a non-uniform definition of literacy, which complicates its consistent measurement over time. On the one hand, the census of 1881 distinguishes between literates, semi-literates (able to read but not to write), and illiterates. On the other hand, the 1901 census classifies individuals into just two categories, i.e., literates and illiterates. In order to compute cohort literacy rates, we follow Ciccarelli and Weisdorf (2019) and code as literate any individual who is not recorded as illiterate in the sources. We consequently measure the young women's crude literacy rate as the number of literate females of age 6-14 over the female population of the same age group.[18] This ratio represents our proxy for early-life female education.

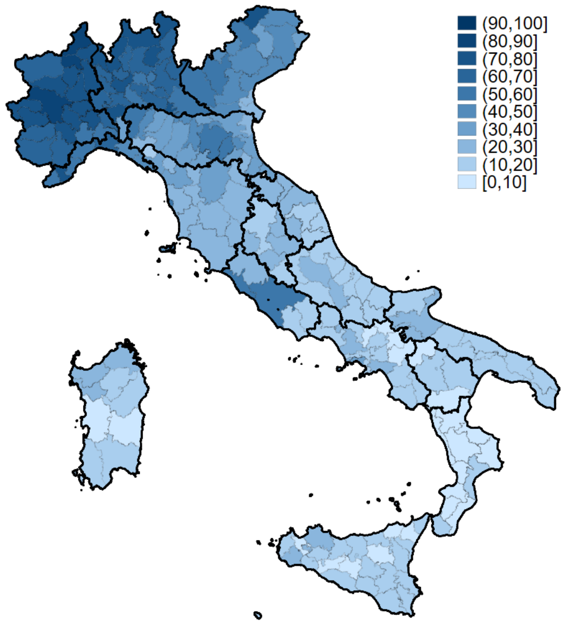
Figure 5, Panels A and B, illustrate the geographical distribution of the literacy rate of women aged 6-14 in 1881 and 1901. Apart from the well-known North-South gradient which persists over time, both maps show substantial within-province heterogeneity. In particular, districts including major cities tend to consistently exhibit a female literacy advantage over their neighbouring areas. This is especially true for the district of Bologna in Emilia-Romagna, the district of Florence in Tuscany, and, even more so, the district of Rome in the single-province region of Latium.[19]

[17]See Section A2 in Online Appendix A for a description of the data harmonization process across the three censuses.

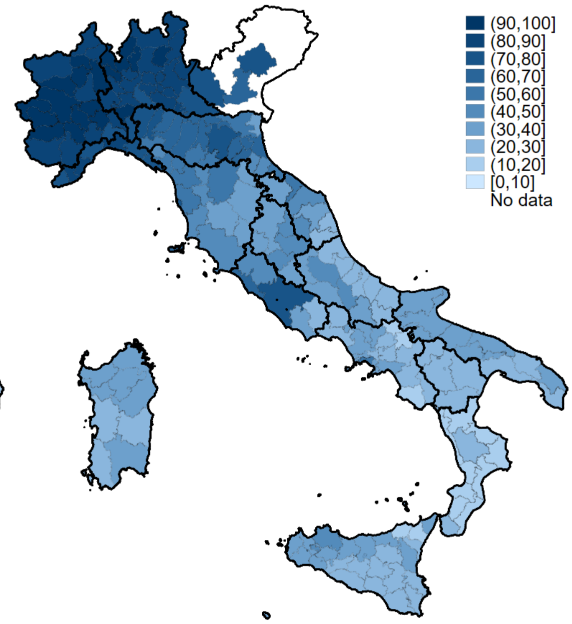
[18]Although compulsory school age in late nineteenth-century Italy was only from age six to ten, also children of older age than ten commonly enrolled in primary schools in that period (Cappelli and Vasta, 2020). Many youngsters took more than five years to complete the mandatory school cycle, owing to either learning problems or, more often, simultaneous school enrolment and workforce participation (Toniolo and Vecchi, 2007). In addition, our approach is aligned with the one used in the 1901 census, where the authors focus on the literacy of pupils in the 6-15 age group when they discuss the impact of the Coppino schooling reform (1877) on the degree of child illiteracy across the kingdom (cf. volume 5, p. LXXI).

[19]In 1901 the crude literacy rate of 6-14-years-old in the district of Rome (74 percent) was 53 percentage points higher than that recorded in the neighbouring Frosinone district. Similarly, in the same year the young female literacy gap between the Florence district and the nearby district of Rocca San Casciano stood at 18 percentage points.

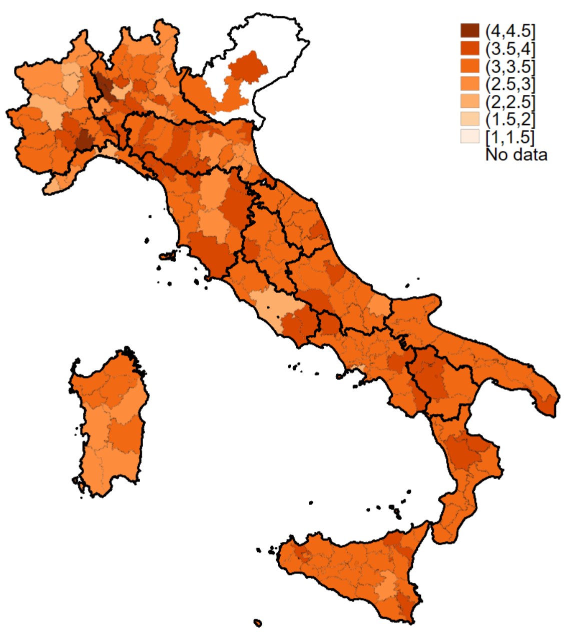
Figure 5: Young Women's Education and Fertility across Italian Districts in 1881, 1901 and 1921



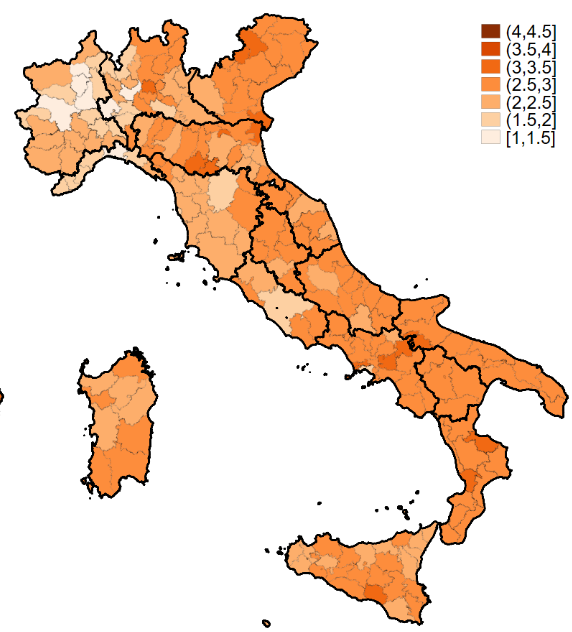
(A) Female literacy rate in 1881.



(B) Female literacy rate in 1901.



(C) Child-woman ratio in 1901.



(D) Child-woman ratio in 1921.

Notes: Literacy rate of women aged 6-14 (in p.p.) and child-woman ratio across Italian districts, in 1881 (only for the former variable), 1901 (for both variables), and 1921 (only for the latter variable). Missing data in 1901 are due to district-level data limitations in the 1901 source for the Veneto region. Region boundaries defined in 1921 are in bold. *Source*: Authors' elaborations on data from 1881, 1901 and 1921 population censuses.

Fertility. District-level birth statistics by age of mother unfortunately are not reported in the official records for our period of interest, so we cannot directly observe the fertility choices (e.g., the average number of children) of a given female cohort in a certain district between 1901 and 1921. Following Becker et al. (2013), we partially overcome this problem by constructing the child-woman ratio, defined as the number of children aged 0-8 in a given year over the number of women aged 25-34 in the same year. The denominator is intended to capture the cohort of women who were aged 6-14 approximately twenty years earlier, thereby linking current fertility outcomes to earlier educational levels. The numerator, in turn, serves as a proxy for their offspring, who are assumed to have been born around their mothers' average age at first marriage (approximately 25 years).[20] This assumption is supported by the fact that the average age at first marriage remained relatively stable in Italy from 1865 until World War I (Livi Bacci, 1977, p. 33). Our approach, in line with the historical evidence, assumes that within-marriage fertility choices outweigh out-of-marriage ones in the Italian historical context.[21] We measure this fertility proxy at the district level for 1901 and 1921 by using population counts by gender and age bins from both censuses, and relate it to young women's education, respectively, in 1881 and 1901.

Figure 5, Panels C and D, depict the distribution of the child-woman ratio across the Kingdom of Italy in 1901 and 1921. Fertility was generally higher in the South than in the rest of the kingdom in both years. Interestingly, it exhibited considerable variation within provinces especially in the North. The fertility decline started in Liguria and Piedmont, two north-western regions that recorded the largest drop in the child-woman ratio over twenty years (respectively 37 and 39 percent). In most southern regions, instead, the fertility decline was much less pronounced by 1921. This pattern is consistent with the long-term influence of French fertility norms in the territories that were part of the Kingdom of France in the early eighteenth century.

Controls. We employ a rich set of control variables that account for both supply and demand factors possibly driving the variation in fertility across Italian districts.[22] All these

[20] In practice, this means that, taking for instance the youngest and oldest cohorts used to compute the female literacy rate in 1881, 6-years-old females in 1881 tended on average to get married in 1900, once they turned 25, and their children were thus likely to be less than 1 year old by 1901, if born in 1900. Similarly, 14-years-old females in 1881 were more likely to get married in 1892 and have children less than 9 years old by 1901.

[21] "Illegitimacy has never had a major impact on the fertility of the Italian population. In Italy—as in most European countries—reproduction takes place mainly within marriage." (Livi Bacci, 1977, p. 69).

[22] According to the theoretical framework outlined by Easterlin and Crimmins (1985), fertility supply factors affect the number of children a couple would expect to bear if no contraception was employed. On the contrary, fertility demand factors impact the number of children actually wanted by a couple. If the potential supply of births exceeds the amount demanded, contraceptive use represents an optimal strategy.

confounders are evaluated in year $t \in \{1881, 1901\}$. A detailed description of these covariates is included in Table A1 (Online Appendix A).

Easterlin and Crimmins (1985) model the demand for children as a function of parental income and the cost of children in relation to other goods. Although district-level data on family income are not available, we control for the rate of urbanization to account for local changes in the income level. We also control for female employment in industry, which influences the fertility demand by changing both the opportunity cost of raising children and the economic return to child rearing (Wanamaker, 2012).[23] Another key driver of fertility demand is culture. By mainly affecting the opportunity cost of female time, cultural norms shape both the relative cost and the economic benefits of having children. In our case, we use proxies for both the influence of the Catholic Church and the historical legacy of the Napoleonic empire in North-Western Italy (Postigliola and Rota, 2021) to capture variation in cultural attitudes towards fertility.

The supply of children in the Easterlin-Crimmins framework depends on individual fecundability and child survival. We account for the former by controlling for the singulate mean age at marriage, the female nuptiality rate and the share of midwives in the female workforce,[24] whereas we measure the latter via the infant mortality rate. Moreover, migration and fertility are strongly interconnected (Livi Bacci, 1977; Bonifazi, 2013).[25] Therefore, we control for emigration as well.[26]

We construct several geographic variables at the district level to control for geographical factors that could affect the diffusion of norms of fertility behaviour. In particular, we

See for instance Dribe (2009) and Becker et al. (2013) for an application of this model to the historical fertility decline in Sweden and Prussia, respectively.

[23]In a largely agrarian and backward economy like the Kingdom of Italy around 1900, the implicit cost of childcare used to be higher for women working in non-agricultural sectors than for those employed on a farm, since the latter could more easily combine work and childminding.

[24]A direct measure of maternal deaths at the district-year level is unfortunately not available. Nevertheless, we expect the share of midwives to (negatively) correlate with maternal mortality, given these workers' crucial role during childbirths.

[25]Besides influencing the fertility supply, Dribe (2009) points out that migration can also contribute to the fertility decision process from the demand side, through the diffusion of knowledge or attitudes about birth control in societies lacking a well-developed information technology. At the same time, migration can hinder fertility in the population of origin through selective out-migration that disproportionately removes healthier or more fertile individuals. This form of selection was particularly pronounced among migrants from southern Italy during the Age of Mass Migration, as shown by Del Boca and Venturini (2005) and Spitzer and Zimran (2018).

[26]Between 1871 and the outbreak of World War II, immigration rates to the Kingdom of Italy were consistently very modest, with foreigners making up around two or three per thousand of the Italian population (Colombo and Sciortino, 2004). At the same time, internal migration within the Italian kingdom was less relevant than migration abroad (Cappelli and Vasta, 2020; A'Hearn and Ciccarelli, 2021). Consequently, in our main analysis we focus only on emigration, also because of the absence of information on internal migration rates at the district level in official sources.

Table 1: Effect of Women's Education on Fertility in the Panel, Baseline Results

Dependent Variable	Child-woman ratio in year $t+20$		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.018***	-0.007**	-0.008**
	(0.003)	(0.003)	(0.004)
District FE	✓	✓	✓
Year FE	✓	✓	✓
Geographic controls × Year FE		✓	✓
Socio-demographic controls in year t			✓
No. observations	402	402	402
No. clusters	201	201	201
Adj. R-squared	0.801	0.836	0.853

Notes: OLS estimates. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by district are reported in parentheses. * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

compute average elevation, average ruggedness and distance to coast. Lastly, to account for pre-existing geographical differentials in fertility, we include in the set of confounders a measure of "contemporary" fertility, namely the number of children aged 0-5 in a given year over the number of fertile-aged women (i.e., women aged 15-49) in the same year.[27]

4 Results

Table 1 presents OLS estimates of Equation (1), our baseline results. In the parsimonious specification in Column 1, which includes only district and year fixed effects, we find preliminary evidence of a negative relationship between early-life female education and fertility. The estimated coefficient $\hat{\beta}_1$ remains negative and statistically significant even after progressively adding our control variables in Columns 2 and 3. In terms of magnitude, the result from the most demanding specification (Column 3) implies that a one standard deviation increase in young women's education predicts fertility, on average, to decline by $\frac{0.008 \times 25.942}{0.563} = 0.37$ standard deviations.

[27]We refer to this variable as the "contemporary" child-woman ratio.

To complement the above analysis, Table 2 reports cross-sectional results obtained from OLS estimation of Equation (2). In each cross section (Panel A and Panel B), we start from a specification without control variables and then gradually introduce confounders in the estimating equation, in the same order. To facilitate comparability of estimates, all variables in this cross-sectional model are standardised to have a mean of zero and a standard deviation of one. The estimated coefficients on education are negative and statistically different from zero throughout the different specifications in both regressions, suggesting once again that districts with less educated young females were more likely to see higher fertility after two decades. The decline in the size of $\hat{\beta}_4$ from Panel A to Panel B in the fully controlled specification (Column 3) is also consistent with the diminishing role of education in shaping fertility patterns as the demographic transition process moved beyond its initial phase, as stressed by Livi Bacci and discussed in Section 2.1.

To produce causal estimates of β_1, we turn to our instrumental variables framework. In Table 3, Panel A, we present OLS estimates of Equation (3), the first stage. In Table 3, Panel B, we instead report 2SLS estimates of Equation (1), the second stage. Covariates are introduced in the same succession in both models. The first-stage results reveal that districts being more distant from the initial female normal schools saw a significantly lower level of young women's education many decades later. The coefficient estimate in Column 3, Panel A, indicates that a one standard deviation increase in distance from female normal schools in 1860 (about 226 kilometres) reduces young female literacy, on average, by 3.8 percentage points. The proposed instrument also exhibits a strong first stage, with the estimated coefficient $\hat{\beta}_7$ proving stable and highly significant across different specifications and the first-stage F-statistic ranging well above the rule-of-thumb threshold of 10, irrespective of the specific set of control variables being considered.[28]

Turning next to the second stage, the 2SLS estimates of β_1 reported in Panel B confirm the significant negative effect of women's education on their fertility behaviour shown in Table 1. Interestingly enough, the size of the 2SLS relationship between these two variables is larger than the one estimated by OLS. This coefficient inflation is consistent with a local average treatment effect (LATE) interpretation of our IV results. More precisely, the effect of young

[28]Lee et al. (2022) argues that conducting valid t-ratio-based inference in a just-identified IV design with one endogenous regressor would require the first-stage F-statistic to range above 104.7 to guarantee a correct size of 5% for a two-sided t-test for the 2SLS coefficient. As the first-stage F-statistic in Table 3 is below this threshold, instrument weakness could still be a major issue in our setting. To rule out this concern, in Table B3 (Online Appendix B) we report weak-instrument robust 95% confidence intervals, constructed either by applying the adjustment factor to the 2SLS-estimated standard errors suggested by Lee et al. (2022) (Panel A) or by using the Anderson-Rubin procedure (Panel B). In both cases the 2SLS-estimated coefficient $\hat{\beta}_1$ is found to be always significant at 5%.

Table 2: Effect of Women's Education on Fertility in the Cross-Section, Baseline Results

Panel A			
Dependent Variable	Child-woman ratio in 1901		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in 1881	-0.321**	-1.465***	-0.631***
	(0.123)	(0.197)	(0.175)
Province FE		✓	✓
Geographic controls			✓
Socio-demographic controls in 1881			✓
No. observations	201	201	201
No. clusters	64	64	64
Adj. R-squared	0.099	0.494	0.753
Dependent variable SD	0.363	0.363	0.363
Independent variable SD	22.844	22.844	22.844

Panel B			
Dependent Variable	Child-woman ratio in 1921		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in 1901	-0.627***	-1.232***	-0.312**
	(0.094)	(0.183)	(0.152)
Province FE		✓	✓
Geographic controls			✓
Socio-demographic controls in 1901			✓
No. observations	201	201	201
No. clusters	64	64	64
Adj. R-squared	0.389	0.695	0.829
Dependent variable SD	0.434	0.434	0.434
Independent variable SD	25.839	25.839	25.839

Notes: OLS estimates. All variables are standardised to have a mean of zero and a standard deviation of one. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by province are reported in parentheses. * = p-value $<$ 10%, ** = p-value $<$ 5%, *** = p-value $<$ 1%.

Table 3: Effect of Women's Education on Fertility in the Panel, IV Results

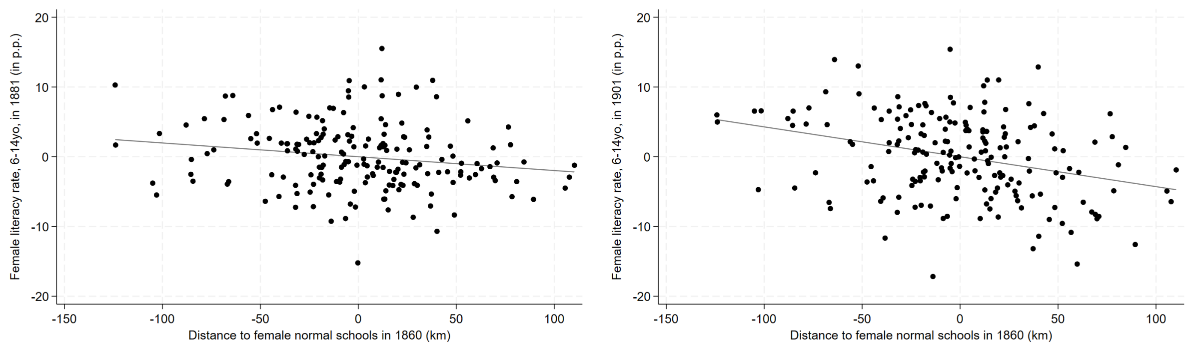
Panel A: first stage Dependent Variable	Female literacy rate, 6-14yo, in year t (in p.p.)		
	(1)	(2)	(3)
Dist. to female normal schools in 1860 × Year FE	-0.016***	-0.016***	-0.017***
	(0.002)	(0.003)	(0.003)
Kleibergen-Paap Wald F-statistic	96.6	39.9	30.9

Panel B: second stage Dependent Variable	Child-woman ratio in year $t + 20$		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.048***	-0.028***	-0.038***
	(0.008)	(0.009)	(0.011)
District FE	✓	✓	✓
Year FE	✓	✓	✓
Geographic controls × Year FE		✓	✓
Socio-demographic controls in year t			✓
No. observations	402	402	402
No. clusters	201	201	201

Notes: OLS estimates (Panel A) and 2SLS estimates (Panel B). Panel B reports the IV estimates where the literacy rate of school-age women is instrumented by the interaction between the distance to the first female normal schools and year fixed effects. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by district are reported in parentheses. * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

women's education on fertility estimated using the IV framework is driven by the behaviour of those districts that reported higher literacy rates for young females only by virtue of being nearest to the first female normal schools, and would not have displayed similar literacy rates otherwise. These districts, the IV "compliers", may have plausibly benefited more from the closeness to the pioneering normal schools than the other districts in our sample. The scenario just described would therefore explain the larger effect size associated with the 2SLS estimator.

Figure 6: First-Stage Relationship Over Time



(A) 1881. (B) 1901.

Notes: Residual plot of the excluded instrument against the literacy rate of school-age females (in p.p.) by year. Both variables are residualised using geographic and socio-demographic covariates, as well as region fixed effects. Geographic controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: crude birth rate in the 1830s, log population density in 1861, urbanization rate in 1861, literacy rate of women aged 4-11 in 1861, and the share of 20-49yo married women over the total female population in 1861. The best linear fit is also reported.

4.1 Instrument Validity

To bolster our confidence in the IV estimates shown in Table 3, we need to demonstrate that our instrumental variable satisfies a number of identifying assumptions.

First, the instrument needs to be relevant. The first stage results presented in Table 3, Panel A, already provide initial support for this IV assumption. We corroborate these findings by visually isolating the identifying variation in the instrument that generates variation in our key explanatory variable. In Figure 6 we graphically represent the first-stage relationship between the literacy rate of school-age females and the distance from the earliest female normal schools, in each year of the panel. As expected, districts located farther from the first female normal schools exhibited lower levels of young female literacy in the late nineteenth century. This negative association, moreover, does not seem to be driven by outliers and strengthens significantly over time, as reflected in the steepening of the linear slopes. These results are consistent with diffusion or cumulative exposure effects, whereby the impact of geographic proximity intensifies as educational infrastructure, information, and social norms gradually spread outward from the locations that hosted the first normal schools.

Second, the instrumental variable needs to be orthogonal to the error term in Equation (1) to satisfy the exclusion restriction. In simpler words, the distance from the pioneering female normal schools (and, by extension, its interaction with year fixed effects) should not impact fertility choices around the turn of the twentieth century, absent the role of women's education. As documented in Section 2.2, the decision over these institutes' location under the Casati Law (1859) was not primarily driven by educational, economic, or demographic criteria. Furthermore, since the distance from the first female normal schools is time-invariant, it is absorbed by district fixed effects and thus cannot directly confound our estimates, a feature that substantially mitigates concerns about the endogeneity of these schools' placement.

In addition to the above arguments, we show that our instrument is not related to variables defined either around 1860 or before. In Figure B1 (Online Appendix B) we report the relationship between distance from the first female normal schools and 16 proxies for social, economic, and political characteristics, reconstructed ex novo from primary sources. These proxies are: the crude birth rate in the 1830s, the urbanization rate in 1861, log population density in 1861, the male and female literacy rate of children aged 4-11 in 1861, the literacy rate of the whole population above the age of four in 1861, the share of married men and women in 1861, the share of unmarried men and women in 1861, the share of men and women employed in agriculture or manufacturing in 1861, and the number of eligible voters as a share of the voting age population (men aged 25 or older) in 1861. We estimate the 1830s birth rate using data from Livi Bacci (1977),[29] while all the other proxies are derived from the population census of 1861.[30] We find no systematic association overall between the excluded instrument and any of these variables. Particularly noteworthy in this respect is the absence of any significant relationship between our instrument and the crude birth rate in the 1830s. These results provide reassuring evidence in favour of the instrument unconfoundedness: the location of the earliest female normal schools was not selected in a way that systematically reflected predetermined differentials in fertility or education determinants across districts.

To lend additional support to the exclusion restriction, we run a falsification exercise where early-life female education is instrumented by the distance from both the first female and male normal schools, computed separately. Figure B2 (Online Appendix B) shows the location of the first male normal schools by the end of 1860.[31] The earliest male normal

[29] Livi Bacci (1977, pp. 21 and 47) points out that territorial variation in fertility levels remained relatively stable from the 1830s through at least the second decade after Italy's unification, implying that the crude birth rate in the 1830s offers an acceptable illustration of the geography of birth rates around 1861.

[30] For men and women employed in agriculture or manufacturing, as well as for eligible voters, the 1861 census reports data only at the province level. We therefore run the corresponding balance checks using the distance from the centroid of each province to the closest female normal school in 1860. All the other balance checks in Figure B1 employ district-level data instead.

[31] Figure B2 highlights eight municipalities: Casale Monferrato, Crema, Lodi, Novara, Oneglia, Pinerolo, Sassari, and Treviglio. The figure does not show the planned male normal school in the Savoy region, for the

schools were set up in the same regions considered for the initial female normal schools, as requested by the Casati Law. However, the exact locations of these male and female schools did not coincide. We therefore compute the shortest distance to the first male normal schools for each district and interact it with year fixed effect, to define a second instrument for the main regressor $Education_{it}$. In Table B4 (Online Appendix B) we report IV results using both our original instrumental variable and the additional one in the same regression. Once again, Panel A illustrates the first-stage estimates, whereas Panel B presents the second-stage results. Since male primary-school teachers were not allowed by law to teach female pupils, we expect to find no significant effect of proximity to the earliest male normal schools on the literacy rate of school-age females. As shown in Panel A, this is indeed the case. Also, the closeness to the first female normal schools remains significantly related to our proxy for young women's education and the relationship between fertility and female education in the second stage remains basically unaltered.[32] These results further support the exclusion restriction.

Finally, the instrument must induce a directionally consistent effect on the endogenous explanatory variable to satisfy the monotonicity assumption. We believe that this condition is implicitly guaranteed by the specific nature of our instrument, as women living farther from a female normal school are unlikely to be more likely to enrol than those living closer, implying the absence of defiers.

4.2 Robustness

In this section we perform a series of robustness checks to assess the stability of our results.

Alternative standard error structures. Tables B5, B6 and B7 (Online Appendix B) show regressions using Conley (1999)'s spatially-adjusted standard errors. Correcting for spatial correlation in the error term leads to estimated standard errors that are very similar to, if not even less conservative than, the clustered ones reported in Tables 1, 2 and 3.

same reasons concerning the planned female normal school in the same region already discussed in Section 2.2.

[32] In Table B4 we use the Sargan-Hansen test of over-identifying restrictions and report the corresponding p-value for each specification. In the regression with the richest set of control variables (Column 3), we fail to reject the over-identification restriction, suggesting that the proposed instruments may be valid. That said, the Sargan-Hansen test assesses whether instruments are exogenous *conditional on them being relevant*. Given that the estimated coefficient on the distance to the first male normal school is never statistically different from zero, this test has very low power and its outcome should therefore be interpreted with caution. Consequently, we favour the just-identified IV setting over the over-identified one and rely only on our main instrument—distance to female normal schools in 1860—when reporting IV results.

Different migration proxy. In the analysis above we always rely on district-level emigration rates to control for the impact of out-migration on fertility. An indirect way to account for both international and internal migration across districts is to use the prime-age sex-ratio, i.e., the ratio of males to females in the 25-44 age group, as done in A'Hearn and Ciccarelli (2021). In Table B8 (Online Appendix B) we replicate the most demanding specifications in Tables 1 and 3 after substituting our proxy for emigration with the prime-age sex-ratio. Including this alternative migration proxy in the regression has little impact on our baseline estimates.

Role of World War I on fertility. In addition to showing the gradual decline in fertility and mortality rates over time, Figure 1 highlights the disruptive impact of the two world wars, and especially World War I (WWI), on Italian demography in the first half of the twentieth century. The first world conflict left important demographic scars on the structure of the Italian population: over 500,000 soldiers died from direct combat, disease, or captivity, with the largest losses occurring in 1918, and the vast majority of deaths concentrated among men aged 19-40 (Fornasin, 2017). The sizeable reduction in the male population of reproductive age caused by WWI, and its repercussions for local marriage markets (for instance through delayed marriages among women), may therefore have substantially affected fertility estimates in 1921. To account for this possibility, we exploit information from the Roll of Honour, a list of 529,028 recorded members of the armed forces who died during WWI, to compute the number of WWI casualties in each district. For each individual, this source reports the municipality and date of birth, as well as the rank and unit at the time of death, and the cause and place of death. Following Acemoglu et al. (2022), we use the municipality of birth to aggregate war casualties spatially. From the same source we obtain the total number of WWI casualties across Italian municipalities, which we then aggregate to the district level. We subsequently divide this figure by the male population over the age of six (from the 1911 census) in all municipalities with recorded war casualties within each district. This procedure allows us to compute the district-level WWI death rate, which we include as an additional control variable in Equation (2), estimated only for $t = 1901$.[33]

Table B9 (Online Appendix B) shows the OLS results of this robustness exercise. The inclusion of the additional covariate does not result in the loss of much relevant variation in the outcome variable and the negative relationship between young women's education and fertility persists. Nevertheless, we cannot completely rule out the possibility that war exposure, sitting between the main explanatory variable and the outcome in time, might be

[33] Given that Acemoglu et al. (2022)'s dataset covers only 5,775 municipalities out of 8,355 listed in the 1921 census, we are able to define our district-level WWI death rate only for 168 districts.

part of the channel through which literacy affected demographic outcomes. If that was true, controlling for the WWI death rate, or for any other descendant of women's education in 1901 along paths to fertility in 1921, would induce an "overcontrol bias" in our estimates. For this reason, we refrain from permanently including this variable to the set of confounders in Equation (2).

Different fertility proxy. When constructing the child-woman ratio, the selection of the cohorts up to 8 years of age in a given year t, defining the ratio numerator, does not take into account the births potentially delivered by the 25-34-years-old women, i.e., the ratio denominator, either before the year $t-8$ or after the year t. At the same time, the numerator of this fertility proxy also includes children aged 0-8 whose mothers are not in the 25-34 age group in the same year t. For both reasons, our dependent variable suffers from measurement error. Still, as long as such measurement error is statistically independent of the literacy rate of school-age females (a reasonable assumption, we believe), the OLS estimator $\hat{\beta}_1$ is unbiased and consistent, although showing a larger variance (Wooldridge, 2009, p. 316).[34]

To strengthen the credibility of our findings so far, we repeat the empirical analysis using an alternative fertility measure: the ratio of the total number of births in a district in a given year to the number of births delivered by a high-fertility reference population—married Hutterite women in the period 1921-1930.[35] The Hutterites are an Anabaptist sect found predominantly in the American Great Plains and the Canadian prairies. In the period between the two world wars, Hutterite women married at very young ages and showed fertility levels that were close to the maximum attainable in a large population. Importantly, Livi Bacci (1977) reports the age-specific birth rates (for five-year age groups) at which Hutterite wives reproduced in that period. We combine these rates with population and births data from, respectively, the censuses and the civil register of the Italian population (*Movimento Annuale dello Stato Civile*), to finally calculate the Hutterite-based fertility index I_{it} as follows:

$$I_{it} = \frac{B_{it}}{\sum_{j=1}^{N} F_j M_{itj}},$$

where B_{it} indicates the total number of children born in district i in year t, j represents

[34] We already explained in Section 3.1 that OLS estimates may remain biased as a result of omitted variables as well as reverse causality.

[35] The first discussion of this variable in the historical demography literature traces back to the Princeton European Fertility Project (Coale and Watkins, 1986). More recent applications of this measure can be found both in the historical demography literature (e.g., Sánchez-Barricarte, 2018) and the economics literature (e.g., Spolaore and Wacziarg, 2022; Ciccarelli et al., 2023).

an age cohort defined at 5-year intervals (15-19, 20-24, and so on until 45-49), F_j denotes the Hutterite fertility rate for age cohort j, and M_{itj} is the number of women in age cohort j living in district i in year t. The denominator of this index therefore corresponds to the maximal reproductive potential of the female population being analysed at the district-year level. As in the case of the child-woman ratio, we compute this variable for all districts in 1901 and 1921 and contrast it with the literacy rates of school-age women, respectively, in 1881 and 1901, again at the district level.

Figure B3 (Online Appendix B) shows the geographical distribution of the Hutterite-based fertility index across Italian districts in 1901 and 1921. The same general patterns observed for the child-woman ratio in Figure 5, Panels C and D, can be distinguished here too, with high fertility levels being consistently more frequent in rural areas and a pronounced fertility decline involving mainly the North-West within this timespan.[36]

In Table B10 (Online Appendix B) we replicate the empirical exercises in Tables 1 and 3 using the fertility index as dependent variable. We find a large, negative and statistically significant effect of early-life female education on the level of later-life fertility, in line with our main results. Despite this consistency, the Hutterite-based fertility index, which captures the fertility behaviour of the *entire female population of reproductive age* (15-49 years) in a given district-year, is less well suited than the child-woman ratio to proxy the specific fertility at time $t + 20$ of women who were aged 6-14 at time t. For this reason, the child-woman ratio, although possibly not immune to measurement error, remains our preferred dependent variable, and we employ the fertility index only for robustness checks.

5 Mechanisms

The negative effect of women's education on fertility identified in Section 4 can be understood through a unifying lens: education expands the set of options available to women, and this expansion generates a reduction in fertility through channels that may reinforce one another. At the individual level, more educated women tend to face a higher opportunity cost of childrearing, either because education enables access to skilled occupations and the associated economic independence, or because it improves their access to information about health and family planning, leading to better child survival and stronger incentives for fertility limitation. Beyond the individual, however, education also reshapes fertility behaviour through broader social channels. More educated women are more likely to spread improved childcare practices and fertility norms within their communities. Female schoolteachers, the most visible

[36] The raw correlation between the fertility index and the child-woman ratio is 0.80 in 1901 ($N = 201$) and 0.92 in 1921 ($N = 214$).

product of the expansion of women's education in post-unification Italy, served as salient role models for the girls they taught. They embodied an alternative ideal of womanhood based on economic autonomy rather than marriage and motherhood, and thereby shaped the fertility aspirations of the next generation. These channels, which we discuss in more detail below under the headings of increased opportunity cost of children ("child cost"), increased women's autonomy within their communities ("empowerment"), and improved knowledge of birth-control practices ("information"), should not be interpreted as alternative explanations. Rather, they represent complementary dimensions of the same underlying process, through which investments in women's human capital reshaped reproductive behaviour across the female population.

With respect to the "child cost" mechanism, more literate women may have access to a wider range of employment opportunities outside their home, thus facing a higher opportunity cost of having children (see for instance Jain, 1981; Moffitt, 1984; Heckman and Walker, 1990; Becker, 1991). At the same time, higher female labour force participation can translate into higher wages, which could enable parents to raise more children (Becker, 1960). According to Becker's quantity-quality theory, however, this income effect is attenuated if parents allocate the additional earnings toward investments in their offspring's education.

With regards to the "empowerment" channel, increases in women's human capital may also enhance their self-determination and bargaining power both within the household and in the broader community (Basu, 2002; Rasul, 2008; Diebolt and Perrin, 2013; Doepke and Tertilt, 2018; Rivera-Garrido, 2022), contributing to a reshaping of the traditional male-breadwinner structure characteristic of pre-transition societies.[37] In this context, more literate women are more likely to enter the labour market or to adopt Malthusian forms of fertility control, such as delaying marriage.[38] Later marriage naturally reduces the number of reproductive years, leading to a decline of fertility.

Lastly, with regard to the "information" mechanism, more educated women may have healthier offspring due to better access to and understanding of information related to health, sanitation, and family planning. As educated women make more informed decisions regarding both their own health and their children's, families are more likely to experience a larger number of surviving children (Basu, 2002) and, consequently, stronger incentives for

[37]Higher female autonomy can, in turn, foster human capital formation, as shown by Baten and de Pleijt (2022) for a large set of European territories between 1500 and 1850. This dynamic could potentially generate a virtuous circle between women's education and female empowerment.

[38]It is worth noting that, for women living in nineteenth-century Italy, employment—especially in industry—often carried significant implications for family planning. Marriage and the birth of a first child frequently resulted in women's withdrawal from the labour market, due to the centrality of family and domestic responsibilities (Casalini, 1981, p. 21).

fertility limitation (Crafts, 1984; Boyer and Williamson, 1989). This effect may be further reinforced if educated women actively diffuse health practices and fertility norms within their communities.

Each of the channels described above provides testable implications, which we investigate using the following cross-sectional model:

$$Y_{ipt+20} = \phi_1\, Education_{ipt} + \phi_2{}' x_{ipt} + \phi_3{}' x_{ip} + \gamma_p + \omega_{ipt+20}, \tag{4}$$

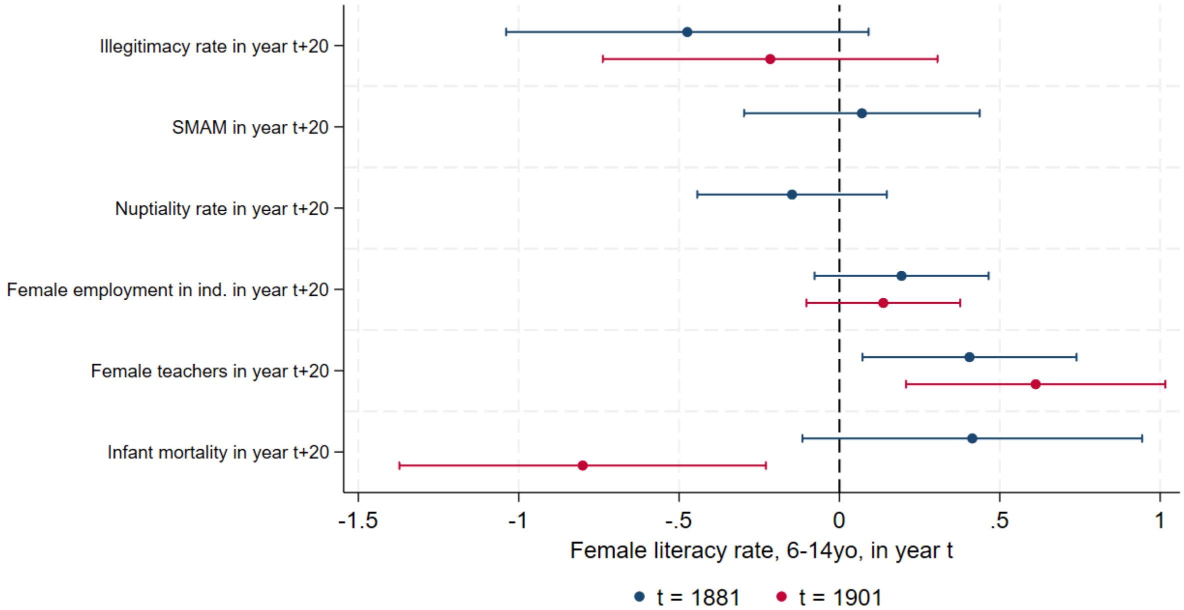
that we estimate separately for $t \in \{1881, 1901\}$. This model closely resembles Equation (2), where each variable is observed for district i in province p and year t (or year $t+20$, in the case of the dependent variable). Here Y_{ipt+20} takes in turn one of the following outcomes: the illegitimacy rate, the mean age at marriage for women, the female nuptiality rate, the share of women employed in industry, the share of women employed as teachers, and the infant mortality rate. We compute all these variables for 1901 and 1921 using data from the respective censuses.[39]

Figure 7 reports standardized OLS estimates of ϕ_1 from Equation (4), for every outcome variable and each time period.[40] The sign of each estimated coefficient is consistent with all the interpretations proposed above (except for the case involving the school-age literacy rate in 1881 and the infant mortality rate in 1901), but the estimates are often too imprecise to draw conclusions. Yet, we see a strong negative correlation of infant mortality rate in 1921 with young women's education in 1901, and also a negative relationship between the illegitimacy rate in 1901 and young women's education in 1881 that is statistically significant at 10%. These results support the "information" mediation channel, as more educated young women could have been more likely to acquire knowledge of contraception methods, thus increasing their use, or to access resources discussing hygiene and disease prevention, leading to lower infant mortality. In a similar vein, education could have facilitated the diffusion of birth-control practices. These conjectures are consistent with the official statements from coeval physicians presented in Pasi (1997) addressing infant mortality across Italy in the late nineteenth century. The scientific community throughout the kingdom made strong efforts to instruct new mothers—through pamphlets, manuals, and magazines—on childcare, but the majority of women were reluctant to abandon harmful local child-rearing practices passed

[39] The 1921 census does not provide district-level information on marital status, so we are unable to measure the mean age at marriage and the nuptiality rate for that year. This implies that some dependent variables in Equation (4) are computed for both 1901 and 1921, whereas others are measured only for 1901. For this reason, we refrain from using a panel method and employ only a cross-sectional model throughout the mechanisms analysis.

[40] Results in tabular format are available in Tables B11 and B12 (Online Appendix B).

Figure 7: Mechanisms: Women's Education and Fertility Supply and Demand Factors



Notes: OLS estimates of Equation (4), for $t = 1881$ (in blue) and $t = 1901$ (in red). Each coefficient shown ($\hat{\phi_1}$) corresponds to a separate regression. The dependent variables Y_{ipt+20} are listed on the y-axis and are all defined at the district level. The explanatory variable $Education_{ipt}$ represents the literacy rate of school-age females in district i in year t. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. All variables are standardised to have a mean of zero and a standard deviation of one. 95% confidence intervals constructed using standard errors clustered by province are reported.

down from one generation to the next.[41] Interestingly, middle-class women, very often those more educated, were the most receptive to these new childcare norms (Pasi, 1997, p. 122). The local transmission of these virtuous health practices took a long time anyway, as "even at the beginning of the twentieth century, this information had still not reached rural mothers, who continued to raise their children as it had always been done" (Pasi, 1997, p. 123).

The only channel for which $\hat{\phi_1}$ from Equation (4) is consistently positive over time and highly statistically significant is the one linking early-life female education with the presence of teachers in the female workforce after 20 years. This result is in line with the fact that,

[41] Many new mothers were accustomed to initiating breastfeeding only after the newborn's baptism or the onset of milk production, thereby delaying breastfeeding by as much as four days after childbirth. Medical recommendations to stop this dangerous practice remained quite often unheard (Pasi, 1997, p. 121).

in the period between the late nineteenth and early twentieth centuries, female teachers across Italy served both as educators and as salient female role models.[42] The typical female schoolteacher of that time was known for devoting herself, with a self-sacrificing spirit, to the education of the working classes, not only in the classroom (Morandini, 2018). In the aftermath of Italy's unification, women appeared to the ruling elite as the preferred subjects for undertaking a "mission" aimed at the literacy of the popular classes (Covato, 1996; Pruneri, 2019), from a perspective of safeguarding moral order and social hierarchies. Despite the rhetorical emphasis on female teaching based on women's "natural" aptitude for children education (Ulivieri, 1977, p. 29), female teachers' actual living conditions at that time were quite miserable: they earned meagre salaries (especially when assigned to teach in rural schools), were bound not to marry, and to remain childless.[43] They were also required by city councils, their effective employer, to maintain irreprehensible conduct, on pain of dismissal.

During the late 1870s, in Italy as well as throughout Europe, the traditional interpretation of women's teaching role began to be challenged, as young women increasingly leveraged the teaching profession to achieve economic and cultural autonomy (Covato, 1996, pp. 21-22). A growing number of young women chose to continue their studies beyond elementary school with the goal of becoming teachers, earning a decent salary, and achieving full emancipation (Bertoni Jovine, 1963), also thanks to two state reforms enacted in 1876 and 1886 that raised teachers' salaries. For schoolteachers, spinsterhood thus became a voluntary sign of economic independence to be displayed with pride, rather than a social status to be passively accepted.[44] As these figures increasingly turned away from marriage, they also distanced themselves from motherhood. More importantly, many female teachers holding emancipationist views exerted significant influence on other female cohorts of the time,

[42] In the case of the United States around 1940, Card et al. (2022) documents a similar "dual role" of female primary-school teachers, who made positive impacts on female students in terms of school enrolment, completed education, lifetime family income and longevity. Importantly, Card et al.'s work does not address the effect of female teachers on their female students' fertility choices.

[43] "Despite the persistent identification between profession and motherhood, the most common status of female elementary-school teachers was that of being unmarried, as prevailing [cultural] attitudes considered it inconceivable to reconcile the roles of wife and mother with employment outside the home." (Pironi, 2019, p. 296). The same point was emphasized by Ferdinando Martini, an influential member of the Italian Parliament, during an open discussion at the Chamber of Deputies in 1883, where he claimed that "no man would want to have as a wife a woman who, for an annual salary of 330 *lire*, spends six, seven, eight hours a day at school." (Soldani, 1993, p. 103). Schoolteaching was also viewed by society at large as such an all-absorbing activity for women that it could "fully satisfy a woman's aspirations, even her maternal ones." (Rocca, 1992, p. 200).

[44] According to Linda Malnati, a female teacher from Milan who was very active in supporting Italian women's emancipation at the turn of the twentieth century, female teachers constituted the social group that provided the largest number of unmarried women during that period. In her view, this was a direct consequence of female teachers effectively managing to achieve economic self-sufficiency (Malnati, 1906).

drawing strength from the growing size of the female teaching workforce and the rise of teaching associations.[45] They participated in public discourse on women's rights, interacted with lower-class families to emphasize the importance of education, and authored educational books for use in schools that promoted a new ideal of womanhood resistant to traditional gender roles (Basso, 2000; Trisciuzzi, 2022). Through these actions, female schoolteachers became important role models for both female pupils and adult women, shaping not only educational aspirations but also fertility choices through their example of largely unmarried and childless women.

6 Conclusion

The demographic transition experienced by several Western countries over the past two centuries represents one of the most consequential transformations in economic history, laying the foundation for the emergence of sustained modern economic growth (Galor, 2022). In this paper we provide new evidence on this epochal change by analysing the onset of the historical decline in birth rates in Italy, a country characterized by substantially greater territorial and social heterogeneity than many other European countries, such as France and England. We examine the impact of women's education on fertility during this historical period using newly digitized district-level panel data, and find that increases in women's education contributed significantly to fertility decline across the country. Our results are robust to addressing potential endogeneity in education by exploiting plausibly exogenous variation in access to the first female teacher-training institutions as an instrumental variable. We also find suggestive evidence that women's economic independence and improved access to information on childrearing and family planning were key mechanisms through which investments in human capital shaped women's reproductive behaviour.

This paper contributes to the broader literature on the European demographic transition by providing novel causal evidence on the role of female education in shaping early fertility decline. It complements previous descriptive and empirical studies about the education-fertility nexus in France, Prussia, and Ireland, while extending the analysis to Italy with geographically disaggregated data and shedding light on potential mechanisms that could apply to other contexts as well. Moreover, it enriches the historical demography literature on Italy, highlighting how local variation in educational opportunities translated

[45] As female schoolteachers grew in number, so did their awareness of belonging to a common professional body, characterised by shared aspirations and shared problems. As a result, thousands of female teachers organized to establish teaching associations. The main one, the *Unione Magistrale Nazionale* (National Teachers' Union), was founded in 1901 and had gathered approximately 20,000 female teachers by 1911 (De Fort, 1981).

into heterogeneous fertility outcomes across districts, in line with theoretical predictions from the child quantity-quality framework.

Future research could extend this analysis over a longer historical horizon, for instance from 1880 to 1980, to examine the relationship between female education and fertility throughout the full progression of the demographic transition. In such a study, district-level data would no longer be usable due to the abolition of districts in 1927, but coarser administrative units, such as provinces or regions, could provide a viable framework for capturing long-term trends. This would allow scholars to explore whether the mechanisms identified at the onset of the transition persisted, evolved, or interacted with broader social and economic changes over the twentieth century.

Official Publications

Ministero di Agricoltura, Industria e Commercio. *Censimento della popolazione del Regno d'Italia...*, various years.

Ministero di Agricoltura, Industria e Commercio. *Statistica della emigrazione italiana...*, various years.

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Online Appendix for: Women's Education and Fertility in Italy at the Onset of the Demographic Transition

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Appendix A Data Description

This Appendix first provides the definition of the variables used in the empirical analysis and the corresponding primary or secondary historical sources consulted to construct them (Table A1). It also provides some details on the main geographical unit of observation, i.e., the district (Section A1), and the cleaning procedure implemented to handle different ways of reporting data on the age structure of the population across censuses (Section A2). Finally, it reports selected articles of the Casati Law (1859) on the Italian educational system (Section A3).

Table A1: Variables Definition and Sources Used

Variable	Year	Definition	Unit of observation	Sources
Fertility				
Child-woman ratio	1901, 1921	Total population aged 0-8 over female population aged 25-34	District	1901 and 1921 censuses
"Contemporary" child-woman ratio	1881, 1901	Total population aged 0-5 over female population aged 15-49	District	1881 and 1901 censuses
Fertility index	1901, 1921	Total number of live births and stillbirths over total number of children potentially generated by female population aged 15-49 under the age-specific fertility schedule of Hutterite women	District	1899-1901 and 1920-1922 civil registers; 1901 and 1921 censuses; Livi Bacci (1977)
Crude birth rate	1830s	Total number of births over total population (in 1,000s)	District	Livi Bacci (1977), Table 1.8
Illegitimacy rate	1901, 1921	Total number of illegitimate births over total number of births	District	1899-1901 and 1920-1922 civil registers
Education				
Young women's literacy rate	1861, 1881, 1901	Women aged 6-14 (in 1881 and 1901) or 4-11 (in 1861) able to read and write over female population of same age group	District	1861, 1881 and 1901 censuses
Young men's literacy rate	1861	Men aged 4-11 able to read and write over male population of same age group	District	1861 census

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Table A1 – *Continued from previous page*

Variable	Year	Definition	Unit of observation	Sources
Distance to female normal schools	1860	Distance from district centroid to the closest female normal school being active in 1860	District	Executive decrees of Casati Law (1859)
Distance to male normal schools	1860	Distance from district centroid to the closest male normal school being active in 1860	District	Executive decrees of Casati Law (1859)
Female teachers	1881, 1901, 1921	Female teachers over female population aged 9+ (in 1881 and 1901) or aged 10+ (in 1921)	District	1881, 1901 and 1921 censuses
Socio-economic characteristics				
Log population density	1861, 1881, 1901	Total population per km^2 (in logs)	District	1861, 1881 and 1901 censuses
Urbanization rate	1861, 1881, 1901	Total population living in towns with more than 20,000 inhabitants over total population	District	1861, 1881 and 1901 censuses
Female employment in industry	1881, 1901, 1921	Women employed in industry (net of textile sector) over female population aged 9+ (in 1881 and 1901) or aged 10+ (in 1921)	District	1881, 1901 and 1921 censuses
Church influence	1881, 1901	Churchmen over total population	District	1881 and 1901 censuses

(Continues on next page)

Table A1 – *Continued from previous page*

Variable	Year	Definition	Unit of observation	Sources
Napoleonic empire legacy	1814	Dummy equal to 1 if the district was part of the Napoleonic empire in the period 1805-1814, and equal to 0 otherwise	District	Postigliola and Rota (2021)
Singulate mean age at marriage	1881, 1901	Average age at which women first marry	District	1881 and 1901 censuses
Female nuptiality rate	1861, 1881, 1901	Married women aged 20-49 (in 1881), aged 21-49 (in 1901), or overall (in 1861), over female population of same age group	District	1861, 1881 and 1901 censuses
Male nuptiality rate	1861	Married men over male population	District	1861 census
Female singleness rate	1861	Unmarried women over female population	District	1861 census
Male singleness rate	1861	Unmarried men over male population	District	1861 census
Midwives presence	1881, 1901	Midwives over female population aged 9+	District	1881 and 1901 censuses
Infant mortality rate	1881, 1901, 1921	Total number of deaths below the age of one (proxied by total number of live births net of population below the age of one) over total number of live births	District	1881, 1900 and 1921 civil registers; 1881, 1901 and 1921 censuses

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Table A1 – *Continued from previous page*

Variable	Year	Definition	Unit of observation	Sources
Emigration	1881, 1901	Average number of emigrants (both permanent and temporary) in years $\{t, t-1, t-2\}$ over total population in year t	District	1879-1881 and 1899-1901 official emigration statistics
Prime-age sex-ratio	1881, 1901	Men aged 25-44 over women of same age group	District	1881 and 1901 censuses
WWI deaths	1881, 1901	Total number of casualties among World War I foot soldiers over male population aged 6+ in 1911	District	Acemoglu et al. (2022); 1911 census
Family nuclei	1861	Number of families over total population	District	1861 census
Women employed in agriculture	1861	Women employed in agriculture over female population	Province	1861 census
Men employed in agriculture	1861	Men employed in agriculture over male population	Province	1861 census
Women employed in manufacturing	1861	Women employed in manufacturing over female population	Province	1861 census
Men employed in manufacturing	1861	Men employed in manufacturing over male population	Province	1861 census
Electorate size	1861	Eligible voters in the 1861 general election over male population aged 25+	Province	1861 census

(Continues on next page)

Table A1 – *Continued from previous page*

Variable	Year	Definition	Unit of observation	Sources
Geography				
Average elevation		Average elevation of district using district borders from 1921	District	GLOBE project (1999), ISTAT (2024)
Average ruggedness		Average ruggedness of district using district borders from 1921	District	Nunn and Puga (2012); ISTAT (2024)
Distance to coast		Distance from district centroid to closest coast	District	ISTAT (2024)

Notes: When employing births data from the annual civil registers, we follow Livi Bacci (1977) and compute, for each district, the average annual number of births during a three-year period centred on the year of reference. This means that, for instance, the total number of births in district i in 1921 used in our calculations equals the average number of births observed in district i in 1920, 1921 and 1922. The textile sector is not included in the measurement of the female industrial labor force, owing to the anomalous representation of the distribution of textile workers employed in factories across the Italian kingdom in the early post-unification censuses (Ciccarelli and Missiaia, 2013). The singulate mean age at marriage is computed using the formula introduced by Hajnal (1953).

A1 On Italian Districts

From 1861 to 1927 the Kingdom of Italy was characterised by four main levels of territorial division: the largest was the region (*compartimento*), followed by the province, the district (*circondario*), and the municipality (*comune*). In 1921, the last year of our interest, each province had on average about 562,500 inhabitants, whereas the average district population was about 163,000 (ISTAT, 2018).

Before being abolished in 1927, the Italian districts underwent a gradual consolidation process over time that changed their total number from 284 in 1881 to 276 in 1912 (Royal Decree no. 554, May 19, 1912) and 214 in 1915 (Royal Decree no. 148, February 4, 1915). We use district borders from 1921. Although we do not consider the 31 districts belonging to Julian Venetia and Trentino that became part of the Italian kingdom in 1920, our estimation sample includes only 201 districts, since the census of 1901 lacks district-level data for 13 districts (all located in the Veneto region).

A2 On the Homogenization of Italian Population Censuses

The three population censuses of 1881, 1901 and 1921 were organised by the General Statistics Department of the Ministry of Agriculture, Industry, and Trade, and were conducted, respectively, on December 31, 1881, on February 10, 1901, and December 1, 1921. The data structure of the 1901 census noticeably differs from the one characterising the other two censuses, owing to a technical adjustment made to the family questionnaire that replaced the age question with a question about the year of birth. As a result, all the population counts in the census of 1901 are reported by year of birth rather than by (either single-year or five-year) age group, unlike the 1881 and 1921 censuses. For consistency purposes, we therefore ignore anyone reported to have been born in 1901 (i.e., between January 1 and February 9) and treat all those born in 1900 as aged 0-1, all those born in 1899 as aged 1-2, and so on.

A3 On the Casati Law

Law n. 3725 of 13th November 1859 (Casati Law)

Original version in Italian:

[...] TITOLO V. DELL'ISTRUZIONE ELEMENTARE. CAPO I – Oggetto ed obbligo dell'insegnamento.

Art. 324. L'insegnamento nelle scuole elementari femminili sarà dato da maestre aventi l'idoneità voluta da questa legge per i maestri.

[...] TITOLO V. DELL'ISTRUZIONE ELEMENTARE. CAPO V – Delle scuole normali.

Art. 357. Sono istituite nove scuole normali per gli allievi maestri, delle quali una nella Savoia, una nella Sardegna, una nella Liguria, tre nelle altre antiche provincie dello Stato e tre nelle nuove. Egual numero di scuole normali colla medesima distribuzione è pure stabilito per le allieve maestre.

Art. 358. Le materie d'insegnamento in tali istituti sono: 1. la lingua e gli elementi di letteratura nazionale; 2. gli elementi di geografia generale; 3. la geografia e la storia nazionale; 4. l'aritmetica e la contabilità; 5. gli elementi di geometria; 6. nozioni elementari di storia naturale, di fisica e di chimica; 7. norme elementari di igiene; 8. disegno lineare e calligrafia; 9. la pedagogia. Nelle scuole normali per le maestre è aggiunto lo insegnamento dei lavori proprii al sesso femminile; in quelle pei maestri può essere aggiunto un corso elementare d'agricoltura e di nozioni generali sui diritti e doveri dei cittadini in relazione allo Statuto, alla legge elettorale ed all'amministrazione pubblica.

Art. 359. L'insegnamento delle materie predette si compie in tre anni. Esso però verrà ripartito in guisa, che dopo due anni di corso gli allievi possano essere abilitati all'esame per la patente del corso inferiore delle scuole elementari, e dopo tre anni all'esame per la patente del corso superiore delle scuole medesime.

[...]

Art. 363. Agli stipendi [*dei professori titolari, ndr*] provvede lo Stato; ai locali ed agli arredi [*delle scuole normali, ndr*] provvedono i Comuni nei quali l'istituto è posto.

Art. 364. Per l'ammissione alle scuole normali si richiede: 1. L'età di 16 anni compiuti per gli alunni, e di 15 per le alunne; 2. Un attestato del Consiglio delegato del Comune o dei Comuni, in cui l'aspirante ebbe domicilio per tre anni, che lo dichiari per la sua distinta moralità degno di dedicarsi all'insegnamento; 3. Un attestato di un Medico che esso non abbia alcuna malattia od alcun difetto corporale che lo renda inabile all'insegnamento; 4. L'aver superato l'esame d'ammissione, giusta i programmi prescritti.

Our translation in English:

[...] CHAPTER V. ON PRIMARY EDUCATION. TITLE I – Subject and obligation of teaching.

Article 324. Teaching in female elementary schools shall be provided by female teachers possessing the qualifications required by this law for male teachers.

[...] CHAPTER V. ON PRIMARY EDUCATION. TITLE V – On normal schools.

Article 357. Nine normal schools for aspiring male teachers are hereby established, of which one to be located in the Savoy region, one in Sardinia, one in Liguria, three in the old provinces of the Kingdom and three in the new ones. The same number of normal schools for aspiring female teachers is also established, following the same geographical distribution.

Article 358. The subjects taught in these normal schools are: 1. the national language and elements of national literature; 2. elements of general geography; 3. national geography and history; 4. arithmetic and bookkeeping; 5. elements of geometry; 6. elementary notions of natural history, physics, and chemistry; 7. elementary rules of hygiene; 8. linear drawing and calligraphy; 9. pedagogy. In the normal schools for female teachers, instruction in work proper to the female sex is added; in those for male teachers, an elementary course in agriculture and general notions of the rights and duties of citizens in relation to the [Albertine] Statute, the electoral law, and public administration may be added.

Article 359. Instruction in the aforesaid subjects is completed in three years. It is, however, arranged so that, after two years of study, pupils can qualify to sit the examination for the license for the lower course of elementary schools, and after three years, for the examination for the license for the upper course of the same schools.

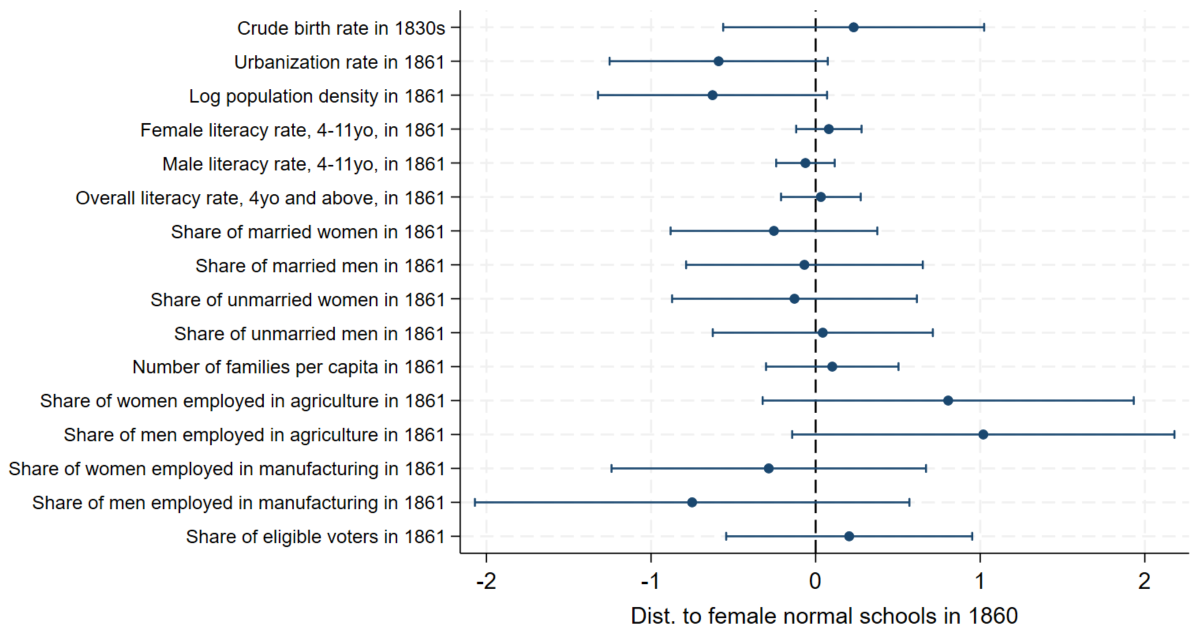
[...]

Article 363. The State covers the salaries [*of the normal schools' professors, authors' note*]; the municipalities in which the institute is located provide the premises and furnishings [*of the normal schools, authors' note*].

Article 364. Admission to the normal schools required: 1. A minimum age of 16 for male students and 15 for female students; 2. A certificate from the delegated council of the municipality or municipalities in which the applicant had resided for three years, attesting to his or her exemplary moral character and suitability for teaching; 3. A certificate from a physician stating that the applicant did not suffer from any illness or physical defect that would render him or her unfit for teaching; 4. Successful completion of the entrance examination, in accordance with the prescribed programmes.

Appendix B Additional Figures and Tables

Figure B1: Instrument Balance Checks

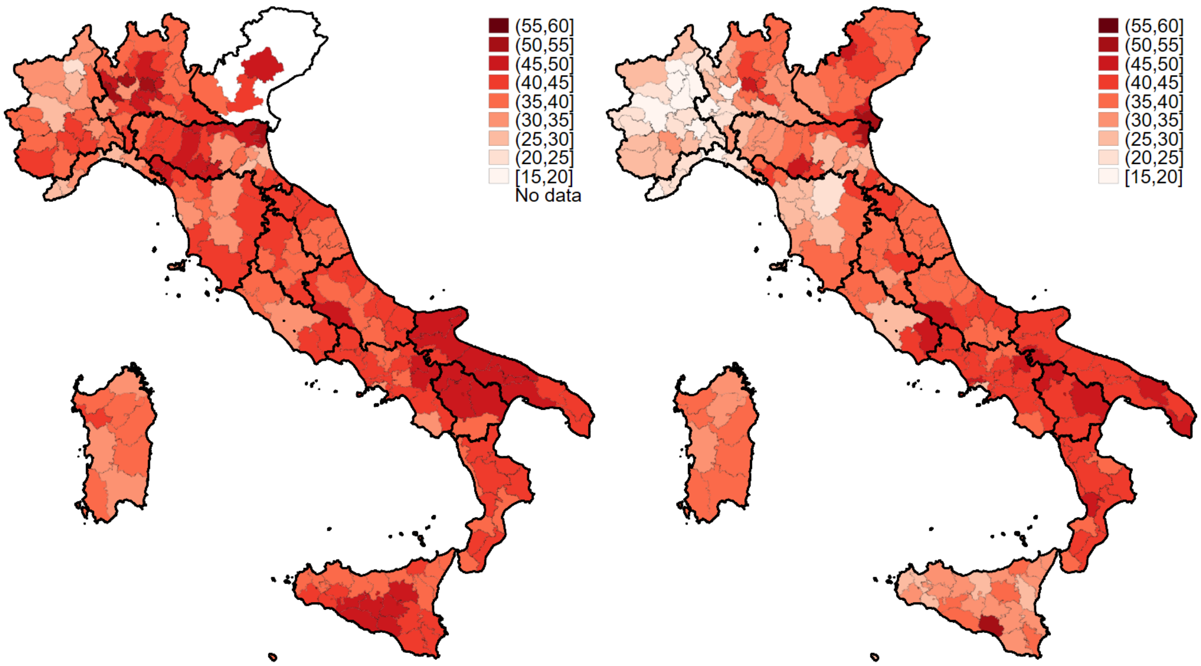


Notes: OLS estimates of cross-sectional regressions of the form: $Y_{ir} = \beta\, NormalSchool_{ir\,1860} + \alpha_r + \omega_{ir}$. Each coefficient shown ($\hat{\beta}$) corresponds to a separate regression. The dependent variables Y_{ir} are listed on the y-axis and are defined either at the district level or at the province level, based on data availability (see Footnote 30). The explanatory variable $NormalSchool_{ir\,1860}$ represents the distance from district i (or province i) to the closest female normal school existing in 1860, i.e., the instrumental variable used in the main analysis. All variables are standardised to have a mean of zero and a standard deviation of one. α_r indicates region fixed effects. 95% confidence intervals constructed using standard errors clustered by province (when data are at the district level) or heteroscedasticity-robust standard errors (when data are at the province level) are reported.

Figure B2: The First Male Normal Schools in Italy

Notes: Municipalities hosting a male normal school by the end of 1860 (blue circles). Regional borders from 1921 are in bold. *Source*: Executive decrees of Casati Law (1859).

Figure B3: Alternative Proxy for Fertility



(A) Fertility index in 1901.

(B) Fertility index in 1921.

Notes: Fertility index across Italian districts in 1901 and 1921, defined as follows: $I_{it} = \frac{B_{it}}{\sum_{j=1}^{N} F_j M_{itj}}$, where B_{it} indicates the total number of children born in district i in year t, j represents an age cohort defined at 5-year intervals, F_j denotes the number of births per woman in age cohort j from the high-fertility reference population (i.e., married Hutterite women in the period 1921-1930), and M_{itj} is the number of women in age cohort j living in district i in year t. See Section 4.2 for further details. Regional borders from 1921 are in bold. *Sources*: Authors' elaborations on data from 1899-1901 and 1920-1922 civil registers, 1901 and 1921 population censuses, and Livi Bacci (1977).

Figure B4: Map of Post-Unification Italy, with Regional Boundaries

Notes: Figure B4 presents a map of post-unification Italy with its regional boundaries. The map displays the sixteen administrative regions of the time. The Casati Law was enacted in 1859, at a time when the Italian state was still in the making. At that point, only four of the regions shown in the map were part of the nascent Italian kingdom: Piedmont, Liguria, Sardinia, and Lombardy. The first three regions formed the Kingdom of Sardinia, the pre-unification state that drove the entire process of Italian unification, along with Lombardy, which had just been annexed following the Second Italian War of Independence. The regions belonging to the Kingdom of Sardinia at the time of the law's enactment are identified in the map by a diagonal hatching pattern.

Table B1: Summary Statistics

Variable	Years	N	Mean	SD	Min	Max
Child-woman ratio	1901, 1921	402	2.883	0.563	1.133	4.223
Fertility index (in p.p.)	1901, 1921	402	37.490	7.181	15.432	53.063
"Contemporary" child-woman ratio	1881, 1901	402	0.604	0.070	0.388	0.807
Young women's literacy rate (in p.p.)	1881, 1901	402	41.824	25.942	4.364	96.332
Singulate mean age at marriage	1881, 1901	402	24.305	1.446	20.768	28.527
Female nuptiality rate (in p.p.)	1881, 1901	402	69.206	5.960	48.188	80.782
Infant mortality rate (in p.p.)	1881, 1901	402	19.487	8.978	0	47.306
Urbanization rate (in p.p.)	1881, 1901	402	16.055	21.850	0	100
Female employment in industry (in p.p.)	1881, 1901	402	5.001	3.243	0.410	20.729
Midwives presence (n p.p.)	1881, 1901	402	0.096	0.038	0.012	0.281
Church influence (per mille)	1881, 1901	402	4.065	1.577	1.175	13.646
Emigration rate (per mille)	1881, 1901	402	7.760	9.759	0	49.518
Prime-age sex-ratio	1881, 1901	402	0.973	0.156	0.567	2.229
Log population density	1881, 1901	402	4.644	0.708	2.586	8.100

Table B2: Distance to the First Female Normal Schools and Presence of Female Teachers

Dependent Variable	Share of female teachers in 1881			Share of female teachers in 1901			Share of female teachers in 1921		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dist. to female normal schools in 1860	-0.743***	-0.451***	-0.280***	-0.759***	-0.481***	-0.301***	-0.633***	-0.503***	-0.467***
	(0.068)	(0.104)	(0.098)	(0.069)	(0.124)	(0.103)	(0.065)	(0.128)	(0.142)
Geographic controls		✓	✓		✓	✓		✓	✓
Socio-demographic controls			✓			✓			✓
No. Observations	201	201	188	201	201	188	201	201	188
No. Clusters	64	64	58	64	64	58	64	64	58
Adj. R-Squared	0.550	0.636	0.763	0.574	0.639	0.781	0.398	0.445	0.488
Dependent variable SD	0.194	0.194	0.194	0.212	0.212	0.212	0.244	0.244	0.244
Independent variable SD	225.838	225.838	225.838	225.838	225.838	225.838	225.838	225.838	225.838

Notes: OLS estimates. All variables are standardised to have a mean of zero and a standard deviation of one. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: crude birth rate in the 1830s, log population density in 1861, urbanization rate in 1861, literacy rate of women aged 4-11 in 1861, and the share of 20-49yo married women over the total female population in 1861. Standard errors clustered by province are reported in parentheses. Data on crude birth rate in the 1830s are only available for 188 districts. * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

Table B3: Weak-Instrument Robust Confidence Intervals

Dependent Variable	Child-woman ratio in year $t + 20$		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.048	-0.028	-0.038
[CI using 0.05 tF standard errors]	[-0.064, -0.032]	[-0.047, -0.009]	[-0.064, -0.011]
[Anderson-Rubin CI]	[-0.064, -0.035]	[-0.046, -0.013]	[-0.063, -0.019]
District FE	✓	✓	✓
Year FE	✓	✓	✓
Geographic controls × Year FE		✓	✓
Socio-demographic controls in year t			✓
No. observations	402	402	402

Notes: 2SLS estimates. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. 95% weak-instrument robust confidence intervals constructed using, alternatively, the tF procedure described in Lee et al. (2022) or the Anderson-Rubin test, are reported in squared brackets. We compute the latter confidence intervals using the Stata package `twostepweakiv` (Sun, 2018) based on the two-step approach of Andrews (2018).

Table B4: Effect of Women's Education on Fertility, Placebo Test

Panel A: first stage Dependent Variable	Female literacy rate, 6-14yo, in year t (in p.p.)		
	(1)	(2)	(3)
Dist. to female normal schools in 1860 × Year FE	-0.018**	-0.023**	-0.025***
	(0.009)	(0.009)	(0.010)
Dist. to male normal schools in 1860 × Year FE	0.003	0.006	0.008
	(0.008)	(0.008)	(0.009)
Kleibergen-Paap Wald F-statistic	47.9	20.0	15.3
Sargan-Hansen p-value	0.404	0.070	0.895

Panel B: second stage Dependent Variable	Child-woman ratio in year $t + 20$		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.048***	-0.030***	-0.038***
	(0.008)	(0.009)	(0.011)
District FE	✓	✓	✓
Year FE	✓	✓	✓
Geographic controls × Year FE		✓	✓
Socio-demographic controls in year t			✓
No. observations	402	402	402
No. clusters	201	201	201

Notes: OLS estimates (Panel A) and 2SLS estimates (Panel B). Panel B reports the IV estimates where the literacy rate of school-age women is instrumented by both the distance to the first female normal schools (interacted with year fixed effects) and the distance to the first male normal schools (interacted with year fixed effects). Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by district are reported in parentheses. * = p-value $< 10\%$, ** = p-value $< 5\%$, *** = p-value $< 1\%$.

Table B5: Baseline Results in the Panel, Conley Standard Errors

Dependent Variable	Child-woman ratio in year $t+20$		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.018***	-0.007***	-0.008***
[50 km cut-off]	(0.003)	(0.003)	(0.003)
[100 km cut-off]	(0.004)	(0.003)	(0.003)
[150 km cut-off]	(0.004)	(0.003)	(0.003)
District FE	✓	✓	✓
Year FE	✓	✓	✓
Geographic controls × Year FE		✓	✓
Socio-demographic controls in year t			✓
No. observations	402	402	402

Notes: OLS estimates. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Conley's standard errors accounting for spatial correlation with Bartlett kernel decay in space are reported in parentheses. We allow errors to be correlated within a circle of radius 50, 100, or 150 kilometres around each district centroid, following the methodology introduced by Colella et al. (2019). * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

Table B6: Baseline Results in the Cross-Section, Conley Standard Errors

Panel A			
Dependent Variable	Child-woman ratio in 1901		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in 1881	-0.321***	-1.465***	-0.631***
[50 km cut-off]	(0.093)	(0.207)	(0.156)
[100 km cut-off]	(0.105)	(0.184)	(0.159)
[150 km cut-off]	(0.099)	(0.172)	(0.159)
Province FE		✓	✓
Geographic controls			✓
Socio-demographic controls in 1881			✓
No. observations	201	201	201
Dependent variable SD	0.363	0.363	0.363
Independent variable SD	22.844	22.844	22.844

Panel B			
Dependent Variable	Child-woman ratio in 1921		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in 1901	-0.627***	-1.232***	-0.312***
[50 km cut-off]	(0.077)	(0.172)	(0.118)
[100 km cut-off]	(0.105)	(0.175)	(0.117)
[150 km cut-off]	(0.114)	(0.169)	(0.114)
Province FE		✓	✓
Geographic controls			✓
Socio-demographic controls in 1901			✓
No. observations	201	201	201
Dependent variable SD	0.434	0.434	0.434
Independent variable SD	25.839	25.839	25.839

Notes: OLS estimates. All variables are standardised to have a mean of zero and a standard deviation of one. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Conley's standard errors accounting for spatial correlation with Bartlett kernel decay in space are reported in parentheses. We allow errors to be correlated within a circle of radius 50, 100, or 150 kilometres around each district centroid, following the methodology introduced by Colella et al. (2019). * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

Table B7: IV Results in the Panel, Conley Standard Errors

Dependent Variable	Child-woman ratio in year $t+20$		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.048***	-0.028***	-0.038***
[50 km cut-off]	(0.007)	(0.007)	(0.008)
[100 km cut-off]	(0.010)	(0.009)	(0.010)
[150 km cut-off]	(0.011)	(0.010)	(0.010)
District FE	✓	✓	✓
Year FE	✓	✓	✓
Geographic controls × Year FE		✓	✓
Socio-demographic controls in year t			✓
No. observations	402	402	402
Kleibergen-Paap Wald F-statistic [50 km cut-off]	142.7	72.6	55.4
Kleibergen-Paap Wald F-statistic [100 km cut-off]	93.7	51.0	41.4
Kleibergen-Paap Wald F-statistic [150 km cut-off]	72.1	39.7	31.5

Notes: 2SLS estimates. The panel reports the IV estimates where the literacy rate of school-age women is instrumented by the interaction between the distance to the first female normal schools and year fixed effects. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Conley's standard errors accounting for spatial correlation with Bartlett kernel decay in space are reported in parentheses. We allow errors to be correlated within a circle of radius 50, 100, or 150 kilometres around each district centroid, following the methodology introduced by Colella et al. (2019). * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

Table B8: Effect of Women's Education on Fertility, Sex-Ratio as Proxy for Migration

Dependent Variable	Child-woman ratio in year $t+20$	
	OLS	IV
	(1)	(2)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.014***	-0.053***
	(0.004)	(0.011)
District FE	✓	✓
Year FE	✓	✓
Geographic controls × Year FE	✓	✓
Socio-demographic controls in year t	✓	✓
No. observations	402	402
No. clusters	201	201
Kleibergen-Paap Wald F-statistic		36.3

Notes: OLS estimate (Column 1) and 2SLS estimate (Column 2). Column 2 reports the IV estimate where the literacy rate of school-age women is instrumented by the interaction between the distance to the first female normal schools and year fixed effects. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, sex-ratio of population aged 25-44, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by district are reported in parentheses. * = p-value $<$ 10%, ** = p-value $<$ 5%, *** = p-value $<$ 1%.

Table B9: Baseline Results in the 1901 Cross-Section, Controlling for WWI Casualties

Dependent Variable	Child-woman ratio in 1921		
	(1)	(2)	(3)
Female literacy rate, 6-14yo, in 1901	-0.731***	-1.249***	-0.404**
	(0.103)	(0.174)	(0.178)
WWI death rate	✓	✓	✓
Province FE		✓	✓
Geographic controls			✓
Socio-demographic controls in 1901			✓
No. observations	168	168	168
No. clusters	59	59	59
Adj. R-squared	0.435	0.725	0.847
Dependent variable SD	0.434	0.434	0.434
Independent variable SD	25.839	25.839	25.839

Notes: OLS estimates. All variables are standardised to have a mean of zero and a standard deviation of one. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by province are reported in parentheses. * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

Table B10: Effect of Women's Education on Fertility, Using Fertility Index as Dependent Variable

Dependent Variable	Fertility index in year $t + 20$ (in p.p.)					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Female literacy rate, 6-14yo, in year t (in p.p.)	-0.351***	-0.203***	-0.219***	-0.938***	-0.722***	-0.718***
	(0.050)	(0.057)	(0.052)	(0.125)	(0.147)	(0.177)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Geographic controls × Year FE		✓	✓		✓	✓
Socio-demographic controls in year t			✓			✓
No. observations	402	402	402	402	402	402
No. clusters	201	201	201	201	201	201

Notes: OLS estimates (Columns 1-3) and 2SLS estimates (Columns 4-6). Columns 4-6 report the IV estimates where the literacy rate of school-age women is instrumented by the interaction between the distance to the first female normal schools and year fixed effects. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by district are reported in parentheses. * = p-value < 10%, ** = p-value < 5%, *** = p-value < 1%.

Table B11: Women's Education in 1881 and Intermediate Outcomes in 1901

Dependent Variable	Illegitimacy rate in 1901	SMAM in 1901	Nuptiality rate in 1901	Female employment in industry in 1901	Female teachers in 1901	Infant mortality in 1901
	(1)	(2)	(3)	(4)	(5)	(6)
Female literacy rate, 6-14yo, in 1881	-0.474*	0.070	-0.148	0.194	0.406**	0.414
	(0.283)	(0.184)	(0.148)	(0.136)	(0.167)	(0.265)
Province FE	✓	✓	✓	✓	✓	✓
Geographic controls	✓	✓	✓	✓	✓	✓
Socio-demographic controls in 1881	✓	✓	✓	✓	✓	✓
No. Observations	201	201	201	201	201	201
No. Clusters	64	64	64	64	64	64
Adj. R-Squared	0.789	0.760	0.858	0.834	0.881	0.556
Dependent variable SD	5.694	1.530	5.687	2.955	0.212	4.308
Independent variable SD	22.844	22.844	22.844	22.844	22.844	22.844

Notes: OLS estimates. All variables are standardised to have a mean of zero and a standard deviation of one. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by province are reported in parentheses. * = p-value $<$ 10%, ** = p-value $<$ 5%, *** = p-value $<$ 1%.

Table B12: Women's Education in 1901 and Intermediate Outcomes in 1921

Dependent Variable	Illegitimacy rate in 1921	Female employment in industry in 1921	Female teachers in 1921	Infant mortality in 1921
	(1)	(2)	(3)	(4)
Female literacy rate, 6-14yo, in 1901	-0.216	0.137	0.612***	-0.800***
	(0.261)	(0.120)	(0.202)	(0.286)
Province FE	✓	✓	✓	✓
Geographic controls	✓	✓	✓	✓
Socio-demographic controls in 1901	✓	✓	✓	✓
No. Observations	201	201	201	201
No. Clusters	64	64	64	64
Adj. R-Squared	0.781	0.881	0.717	0.523
Dependent variable SD	3.353	2.377	0.244	5.310
Independent variable SD	25.839	25.839	25.839	25.839

Notes: OLS estimates. All variables are standardised to have a mean of zero and a standard deviation of one. Geographic (time-invariant) controls include: average elevation, average ruggedness, distance to coast, and a dummy for the influence of pre-1814 French empire. Socio-demographic controls include: "contemporary" child-woman ratio, log population density, infant mortality rate, mean age at marriage for women, average emigration rate, urbanization rate, women employed in industry (net of textile) as a share of the female population above the age of nine, midwives as a share of the female population above the age of nine, the share of churchmen over total population, and the share of 20-49yo married women over the female population of same age group. Standard errors clustered by province are reported in parentheses. * = p-value $<$ 10%, ** = p-value $<$ 5%, *** = p-value $<$ 1%.