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Transforming mineral capital into human capital? Mining and education in early twentieth-century Spain[1]

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Using a highly detailed dataset at the municipality level, drawn from the Spanish Mining Cadastre of 1890, this paper shows how the mining sector affected education provision and human capital formation in early twentieth century Spain. The results indicate that there were two patterns in mining towns. Those mines that invested in technology, those highly productive, and those with post-extraction industries linkages were able to transform mineral capital into human capital. However, in areas where mines were characterized by unskilled labour and low living standard, the mining sector had a negative impact on education, especially in women's human capital formation.

1. Introduction

Although the relationship between the mining sector and the industrialization process since the early nineteenth century in Europe and North America has been widely studied, its connection with education is less clear.[2] Although the literature finds a positive relationship between mineral resources and educational attainments, the historical perspective of this phenomenon has been less explored (Aragón and Rud 2013; Douglas and Walker 2017; Juif 2019).[3]

The economic history literature argues that from the eighteenth century, the mining industry was a cutting-edge sector, as steam engines and other advances were created and widely implemented in the sector (Nuvolari and Verspagen 2009; Nuvolari et al. 2011). Following Mokyr et al. (2019), this would have generated spillover effects that boosted education in mining basins due to the demand to create or repair this technology. Moreover, as capital and human capital-intensive industries mushroomed around those mines, more skilled and

[1] Through the paper I use mining sector, mining industry, mineral capital, or mineral wealth meaning all the formal activities that were related with the extraction and pre-smelting process of minerals from mines.

[2] For the relationship between natural resources and industrialisation for Europe see Allen (2009), Fernihough and O'Rourke (2021), Balderston (2010), Crafts and Wolf (2014), Sugden et al. (2018), or Gutberlet (2014). For the USA, see Jones (2010) and Klein and Crafts (2012). For Spain, see Domenech (2008) and Martínez-Galarraga (2012).

[3] Wright and Czelusta (2004) argue that the industrial leadership of the USA came mainly from its natural resource wealth. However, Gylfason (2001) finds a negative relationship between natural resources and educational attainments, although his study is a cross-country analysis, done for the post–mid-twentieth-century period, and accounting only for oil wealth.

educated workers were demanded, especially during the Second Industrial Revolution (Galor and Moav 2004). Furthermore, this concentration process around the mines constituted a turning point with respect to the previous rural-agrarian and self-sufficient local economies. Industrialization, a yearly constant wage as opposed to the seasonality of agriculture, and the increasing market transactions transformed mining-industrial towns into more modern market economies. Thus, the increase in transactions, taxes, and windfalls from the mining sector could have led to greater education provision in these towns, as Maurer (2019) finds for Postbellum USA.

However, the negative effects of mineral wealth on education were also present. During the period under study, the mines were usually labour-intensive in unskilled workers (Samuel 1992, pp. 31–32). Thus, due to these low skill requirements for miners, it has been argued that miners neglected the education of their children, as they would not need it to work at the mines (Humphries 2011, p. 221).[4] Therefore, town councils might not have had the incentive to invest in education as these facilities would be underused by the families. Moreover, due to the demand for unskilled workers at the mines, migration bias might have been triggering a flow of uneducated workers (Pérez-Fuentes Hernández 2004).[5] Similarly, as the demand for minerals rapidly increased throughout the nineteenth century, mining towns experienced a rapid population growth, which could have led to a temporarily underprovision of education and overcrowded schools, which could have affected human capital formation.[6] Finally, extractive patterns could have arisen in the mining towns, whereby mining companies just extracted and shipped the ore to other locations, impeding industrial and post-extraction transformations, and therefore preventing the demand for educated workers from these industries.[7]

Therefore, two patterns could arise in mining towns. First, those where, even though the mines were labour-intensive, capital investment in technology and the presence of post-extraction industries led to a demand for skilled and educated workers, transforming mining capital into human capital. Second, in mining basins with a low capital investment, no linkage with industries and where an extractive model was developed, the mineral wealth could have been expected to have a negative role on education.

Consequently, in order to analyse this relationship between mineral resources and education from a historical perspective, Spain is an interesting case study for two reasons. First, together with the low literacy rates in comparison with Europe, the decentralization of primary education provision until 1902 meant that local characteristics had a significant effect on the access to education. Second, Spain was an important mineral producer until the early twentieth century, and thus it would be interesting to see how local mineral wealth was transformed into local human capital.

Therefore, in order to assess the role of the mining sector on education, the impact of mining on education provision in early twentieth-century Spain is analysed, examining the number of public schools per 10,000 inhabitants in 1903 and whether municipalities complied with the required number of schools indicated by the Education Law of 1857. Moreover, the separate study of female and male literacy rates in 1910 reveals whether mining had gender-specific effects on education.[8] By exploring different aspects of the mining sector, such as the use of steam engines, female and child mining labour or productivity, a better understanding

4 See also John (1984, pp. 26–32) and Kirby (2003, pp. 76–78)
5 For the categorization of miners as unskilled see, for instance, Mitch (1992) or Humphries (2011).
6 Although they do not specifically study mining cases, see for instance Rauscher (2016) and Mitch (1992, p.134).
7 See Acemoglu et al. (2002) for the case of extractive institutions in Latin America.

of the role of this industry in human capital formation can be gained. Furthermore, given that northern and southern Spain were different in many respects, including education provision and literacy rates, the analysis has been conducted separately for these two macro-regions.

The results show that the two mining patterns described above existed in early twentieth century Spain. In the north, the more productive and technologically advanced mines were able to transform their mining wealth into human capital. Moreover, different minerals had different links with education. In the case of copper mines, there was a clear positive role on human capital formation in both regions, which could be related with the local job market demanding more educated and skilled workers. However, in the case of other minerals such as lead, and less important minerals such as mercury or tin, the sector had a negative effect on education. Discarding elements such as the role of foreign companies, or mining ownership concentration, the results indicate that some of these minerals might not have produced enough output or there was no clear linkage to attract post-extraction industries and, therefore, demanded only unskilled/illiterate miners. Moreover, in the more productive southern mines and in the northern coal and iron towns, there was a significant negative effect on women's education. However, this negative effect was not present in the case of males or education provision, which, following the literature, indicates that job prospects and the scarce resources of mining families led them to prioritizing their sons' education. Thus, although the literature stresses the positive industrial linkages of minerals such as iron or coal in historical perspective, which could have fostered men's education, living standards and job prospects in these areas could have acted against female human capital formation.

The structure of the paper is as follows. Section 2 explains the historical background and describes the education and mining contexts in Spain. Section 3 presents the data employed in the analysis. Section 4 describes the methodology used and reports the results, and Section 5 concludes.

2. Historical context

During the nineteenth century, Spain was behind other European countries in the process of the transition to the first stages of industrialization, partially because of the turbulence during the first four decades of the century (Prados de la Escosura and Rosés 2010; Díez-Minguela et al. 2016). The conflicts during this period prevented the effective implementation of a nationwide Education Law until 1857, when the Moyano Law was enacted (Nuñez 1992; Beltrán Tapia et al. 2021).[9] Following previous educational regulations, this Law established that municipalities had to fund primary education with their own revenues. This decentralization was gradually reversed beginning in 1902, when the state started to pay teachers' salaries. Consequently, by the turn of the twentieth century, Spain was far behind other European countries in terms of educational attainment: only 44.8 percent of the population in Spain were literate in 1900; levels that France and the UK had achieved in the early nineteenth century (Vincent 2003; Beltrán Tapia et al. 2021).

[8] I use literacy rates as a measure reflecting school attendance and the accumulation of basic skills. Other educational measurements such as school attendance are not available at municipality level. Although it has been argued that literacy did not measure certain skills, literacy rates will be a measure of the accumulation of basic skills and the process of school attendance, and the demand for schooling at the local economy. See for instance Pleijt and Weisdorf (2017, p. 2).

[9] Nevertheless, the timing of this Educational Law was similar to other European countries, see for instance Westberg et al. (2019).

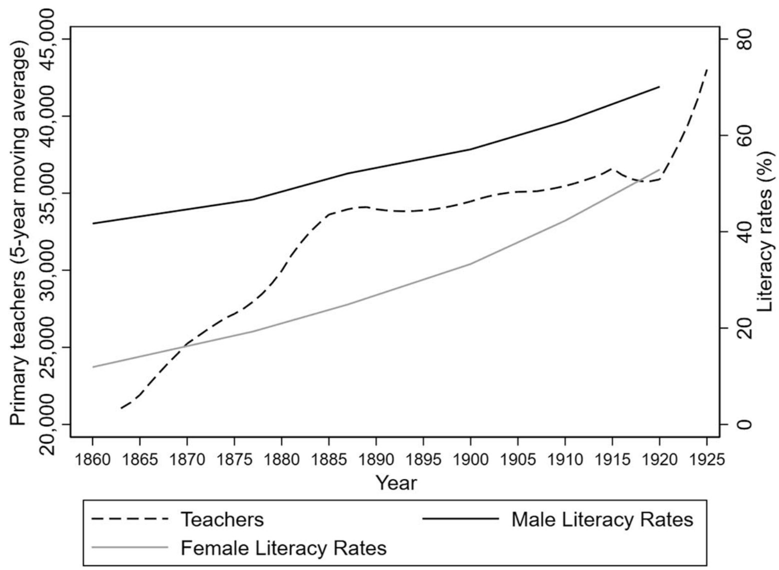

Figure 1. *Primary teachers (left axis) and adult literacy rates (right axis). Note: data for teachers from Nuñez (2005, pp. 208–209, table 3.3, column 534) and for literacy from Beltrán Tapia et al. (2021).*

Figure 1 represents the evolution of education provision, measured as the number of primary teachers and literacy rates for those above 10 years old from the mid-nineteenth century to the early twentieth century. As we can observe, after the implementation of the Education Law in 1857, the number of primary teachers soared until the late 1880s, then stagnated during the last decade of the nineteenth century until 1920. Moreover, the number of schools per children of school age (6–15 years of age) show a similar evolution.[10] By 1860, there were 0.64 schools per 100 children, which increased to 0.87 in 1887 and to 0.88 in 1900, following the increase seen in figure 1 in education provision. However, by 1910 the figure has fallen to 0.83, which was also the number of schools per 100 children in 1920. Therefore, despite the centralization of teachers' wages in 1902, the greater educational provision effort until 1920 was made by the municipalities as the greater increase in the number of teachers happened when primary education was directly provided by towns.

Despite the stagnation seen in primary education provision, literacy rates grew persistently during the period. In 1860, there was a considerable gap between males and females, which slowly decreased from 29.8 percentage points in this year to 17.2 in 1920. This was explained by the rise in female literacy rates from the 1880s, as it increased from 24.9 percent of adult women being literate in 1887 to 52.9 percent in 1920, while men experienced a slightly lower increase rate, from 52.1 percent to 70.1 percent in the same years. Therefore, despite the stagnation in the provision of primary education since the 1880s, the stock of human capital steadily increased throughout the period.

[10] Children of school age is considered between 6 and 15 years old, as this is the only group of age that could be used from the Spanish Population censuses through these official statistics between 1860 and 1920.

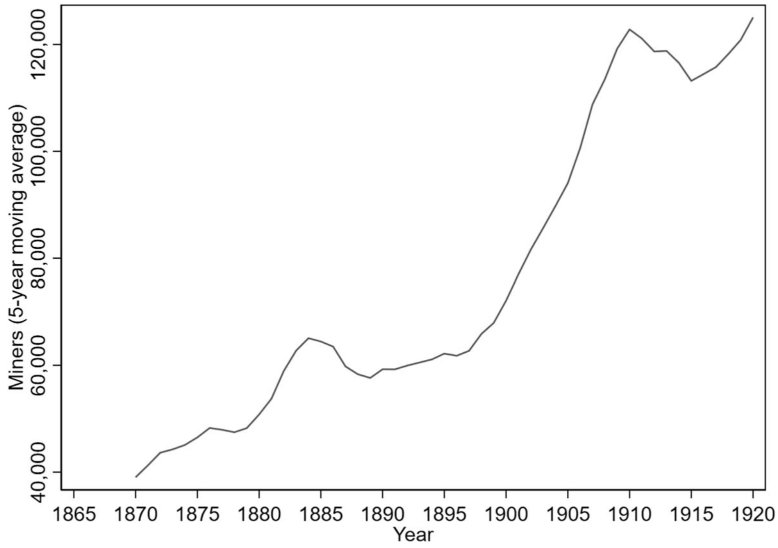

Figure 2. *Employment in the mining sector. Note: data from Estadísticas Mineras from 1866 to 1920.*

Parallel to the Spanish educational process during the nineteenth century, the mining industry flourished, especially in the second half of the century. As the Industrial Revolution spread from the British Isles to the continent, the demand for non-precious minerals soared due to the development of new technologies.[11] Consequently, the Spanish regions that were rich in these natural resources became attractive for both national and foreign investors. Thus, during the second half of the nineteenth century, the Spanish mining industry became the leading producer of lead and copper, as well as an important player in the production of iron ore.[12]

To observe the evolution of the sector, figure 2 presents the 5-year moving average of the number of miners. The graph shows a clear upward trend from the mid-nineteenth century, which accelerated from the last decade of the century. In 1866, the official statistics reported a total of 31,483 miners in Spain, while by 1890 the figure had doubled to 64,962, doubling again in the following two decades, reaching 123,003 miners in 1910.[13] However, the evolution was heterogeneous across the different minerals. For instance, lead mining employment and production were constant throughout the period, employing around 20,000 miners with a steady production of around 300 thousand tons per year from 1870 to 1910. However, copper or iron ore mining started to massively produce in the late 1880s, reaching their peak in terms of employment and extraction during the 1910s, while coal peaked during the late 1910s and early 1920s.

As minerals were fixed to the terrain and had to be extracted to be used, the increasing numbers of miners seen in figure 2 were concentrated around mining sites throughout the

[11] See Allen (2009), and Nuvolari and Verspagen (2009), for the relationship between new technologies and the mining industry during the nineteenth century.

[12] For instance, between 1870 and 1890, Spain produced 25.5 percent of the lead extracted in the world, while the USA produced the second-highest volume, accounting for 23.1 percent of global lead production (Pérez de Perceval Verde and Sánchez Picón 2001).

[13] All the mining data in this section comes from the *Estadísticas Mineras de España* from years 1866 to 1920.

period as the demand for minerals and workers rose. This led to an important population growth in mining towns, which could have affected the education received by children, as the lack of willingness or capacity from mining town councils to provide education was reflected in overcrowded schools (Pérez-Fuentes Hernández 2004). Moreover, an important part of the population growth was due to migration, which had an important effect on local communities (Martínez Soto et al. 2008).[14]

Despite the overall increase in the number of miners during the period, child labour in the mines remained constant at around 15 percent of total miners during the whole period and only started to decrease to below 10 percent during the 1920s. Female mining labour, meanwhile, never represented more than 5 percent of the total miners in official statistics.[15] This low engagement of women in the sector came from the substitution effect that female and child mining labour had, as women and children did the same tasks in the mines (Pérez de Perceval Verde et al. 2020). For instance, in the lead mines of Murcia, surface tasks such as cleaning and classifying the ore were carried out by young males, whereas in the coal mines of Asturias, women undertook these jobs, accounting for around a quarter of the total mining jobs. Moreover, in other mining basins such as Biscay, women had an indirect involvement in the sector, as subsidiary tasks such as cleaning and preparing meals or a boarding house system were carried out by women in these mining towns (Pérez-Fuentes Hernández 2004).

Regarding the use of technology in the Spanish mines, during the second half of the nineteenth century, mines increased the number of steam engines installed, from 144 with 3,651 hp in 1870 to 875 engines with 26,590 hp in 1900. However, during the 1900s, electric and internal combustion engines began to be implemented in the sector.[16] While in 1900, steam engines accounted for 100 percent of the power installed in mines, by 1910, this had decreased to 80 percent, and in 1920 it was 51 percent, in favour of the increasing use of electric engines.

As mentioned above, the foreign role in Spanish mines was important during this period. Foreign capital quickly started to flow into minerals such as copper in Huelva or the iron mines in Biscay during the second half of the nineteenth century. Harvey and Taylor (1987) calculate that in 1890, for copper, iron, and lead mines, 59 percent of the value extracted was controlled by foreign mining companies. This implied that there was an important rise in the importance of minerals in the Spanish exports, increasing from 10 percent of the value exported in 1870 to 25 percent in 1910, only surpassed by agricultural products.[17]

In conclusion, the Spanish case presents several interesting features that can shed light on the link between the mining sector and education. The decentralization of primary education and the low literacy rates in Spain during the nineteenth century provide an interesting framework in which levels of basic human capital accumulation varied depending on local factors. The mining industry might have played an important role in these local differences. Population growth, child and female labour in mines, the use of technology, or the role of foreign firms may have triggered certain mechanisms that hindered or enhanced education in mining towns.

[14] See also González Portilla (2001).

[15] Humphries and Sarasúa (2012) stress that women were generally under-recorded in official statistics, which makes it difficult to determine the precise implication of women in any sector

[16] Electric engines started to be reported in the Statistics of 1907, and internal combustion engines in 1910.

[17] Own elaborations, data for the mining and metal exports from *Cuadro General del Comercio Esterior de España . . . (1855)*, *Estadística General del Comercio Exterior de España . . . (1870)*, *Estadísticas Mineras de España Correspondientes a 1884*, *1900*, and *1910*, and from Harvey and Taylor (1987, p. 186) and Tena (2005, p. 611).

3. Data

In order to analyse the impact of the mining industry on education, this article relies on mining information from 1890 because detailed local information on mines exists for this year only. Nevertheless, while the mining variables were obtained from the Mining Cadastre of 1890, the availability of population and education information from 1860 onwards allowed me to retrieve municipal data for 1860, 1887, 1900, and 1910 from the population censuses for all Spanish municipalities (excluding the Canary Islands), including information on male and female literacy levels, as well as on other demographic variables.

3.1. The Mining Cadastre of 1890

Although the Spanish government started recording mining statistics at the province level in 1862, it was not until 1890 that it published detailed information for all of the mines that were operating at that time. Drawn up by state mining engineers, the Mining Cadastre was issued in the Mining Statistical Report for 1890–1891. It listed information on every mining concession that was active in that year. As well as providing the name of the mine, its owner(s), and the municipality where it was located, the Cadastre indicated the type of mineral extracted, the mining area, the number of workers employed (men, women, and children), whether the mine was open pit or underground, the numbers and types of machines used, the production (both in volume and value), and the numbers of deaths and injuries due to accidents.[18] The Cadastre, therefore, presents an extremely detailed picture of the Spanish mining sector in the late nineteenth century.

Although these statistics have been criticized, especially regarding the possible under-reporting of some of these figures, the data compiled in the Cadastre of 1890 represented a minimum threshold of the importance of the mining industry in Spain.[19] Moreover, as we can see in figure 2, although the mining boom occurred after the Cadastre of 1890 was compiled, the information recorded in this year is a good measure of the importance of the sector. All the mining basins that soared after 1890, such as the copper mines in Huelva, or the iron and coal fields in Biscay and Asturias, respectively, were opened in 1890. Thus, the Mining Cadastre of 1890 and its information reflect an impact on education that could have been even greater in the following years as the mining sector expanded further.

In total, the Cadastre reports that 33 different minerals were extracted in 1,053 mining concessions, which were linked with the Spanish municipality where they were. This result in 272 locations (out of the 9,130 municipalities that existed in Spain in 1887) with at least a mine within their municipal borders. Therefore, a dummy variable has been created, taking one for each one of these 272 towns, in order to interact it with population variables, as explained below. By depicting the numbers of miners, figure 3 illustrates the location and importance of these mining municipalities. The mining industry was concentrated on the northern coast of Spain (mainly Asturias, Cantabria, and Biscay), in Levante (from Murcia to Malaga), in northern Andalusia, and Ciudad-Real and Badajoz. Moreover, the figure displays two regions (north and south) where around 85 percent of the miners in Spain were employed. Given that education was markedly different between Northern and Southern Spain, as it will be seen in the next section, this division is used to provide a more precise picture of the impact of the mining industry on education in the analysis.[20]

[18] See figure A.1 in the appendix for an illustration of the source

[19] See Escudero Gutiérrez (1994) for a critical review on the mining statistics during the nineteenth century.

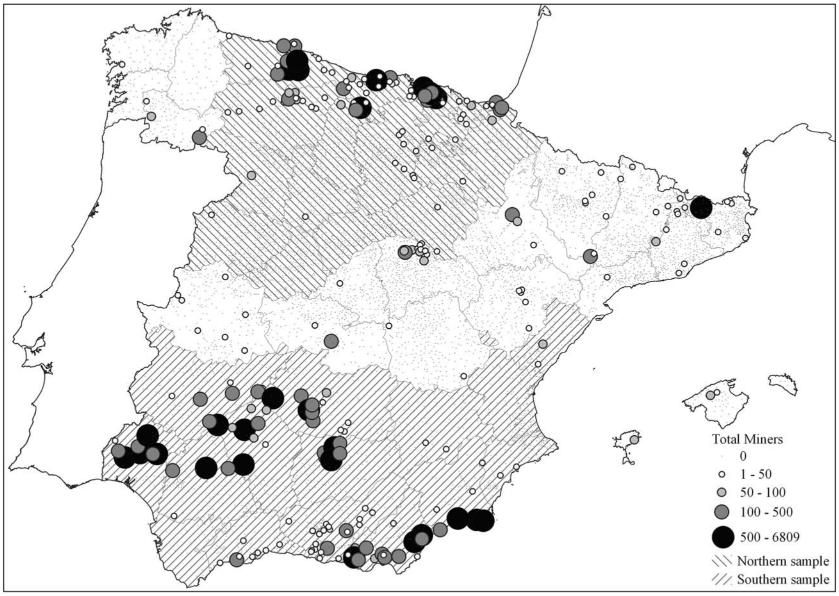

Figure 3. *Total miners in 1890*

The Cadastre, therefore, allows me to assess the importance of the mining sector by computing the percentage of miners over the total population at the municipal level. However, in order to gain a deeper understanding of the sector, this variable is further divided into a variable for the four main minerals (iron, copper, lead, and coal), which account for 90.6 percent of miners in 1890, and a fifth variable for miners in other mines. This distinction will enhance the analysis, as different minerals might have different dynamics with education. Additionally, as the value of the minerals extracted was recorded in the Cadastre, the productivity per miner, in hundreds of *pesetas*, is calculated. This variable will show how richer and more productive mines could be translated into higher revenues for miners, as piecework payments or wages may have been higher.

[20] The division has been made following the information about municipal expenditure on public education, enrolment rates, and number of schools in 1885. Those provinces that had values above the national average in the three categories were included in the north subsample (Álava, Ávila, Burgos, Cuenca, Gipuzkoa, La Rioja, Navarra, Palencia, Salamanca, Segovia, Soria, Valladolid, and Zamora). The provinces of Teruel, Girona, and Lleida are excluded as they do not share borders with the other provinces. In the case of Guadalajara, it is not included because it did not fulfil the educational requirements, (being above the national average), and the mines presented in figure 3 are mainly silver, in opposition with more industrial-related minerals from other mines in the peninsula. Moreover, Biscay, Cantabria, and Asturias are included in this northern sample due to the importance of the mining sector, although they were only above the national average in two of the three categories. The southern subsample is composed of all the provinces that had the provincial value below the national average in municipal expenditure on public education, enrolment rates, and number of schools in 1885 (Albacete, Alicante, Almería, Badajoz, Cádiz, Castellón, Córdoba, Granada, Huelva, Jaén, Málaga, Murcia, Seville, and Valencia). However, similar to the north subsample, the province of Ciudad Real is included although only municipal expenditure on public education and number of schools in 1885 were below the national average because of the importance of the mining sector in this province.

Moreover, this source enables me to capture different employment patterns and household dynamics by computing the percentages of children and women employed in the mining sector. Accounting for the share of child labour allows me to control for the potential living standards of mining families, as a higher percentage of child labour might indicate the need for extra income in mining families, which would have a direct impact on education. Moreover, as mentioned before, obtaining female mining labour would show the substitution effect with child labour, allowing more children to be educated. Figure A.2 in the appendix depicts the distribution of child and female labour. The former was more widespread than female labour in the mining sector. While women worked in the coal mines in Asturias, and on a smaller scale in northern and western Andalusia, child labour was evenly distributed, although the highest rates were in the southern mines and the coal mines in Asturias.

Furthermore, these two variables can be complemented with information about the implementation of modern technology in the mines, as measured by steam horsepower per miner. [21] Therefore, this variable will measure the potential demand for skilled workers from the mining industry. Figure A.3 in the appendix shows that the most mechanized mines in Spain were mainly located in the northern provinces of Andalusia, Cantabria, and the Basque Country, while there were no steam engines in 182 out of the 272 mining towns.

Likewise, as the Mining Cadastre provided information on the owner and the legal address of each concession, the locations where foreign capital was present can be identified, and therefore, the percentage of all miners who were working for a foreign mining company can be computed. Therefore, this variable will shed some light on the role of international companies and on how an extractive pattern may have affected local education. Additionally, as the mining information was gathered by mining concession, the concentration of the mining labour market can be measured. The Theil Concentration Index of workers by mine owner in each mining town allows me to measure the companies' control of the local labour market. Thus, job market competition and opportunities can be captured in order to assess how job market concentration might have affected miners' living conditions, and, in turn, education. Figure A.3 in the appendix shows these two indicators. It illustrates that the presence of foreign companies was evenly distributed across the territory, although it was lower in the south-eastern coast. However, the concentration index also shows that mining ownership was highly concentrated. Most of the mining towns had an index close to two, which means that all miners were working for a single mining owner.

3.2. Public schools census of 1903

The second main variable of interest is gathered from the Schools Census of 1903.[22] This volume was published in 1904 and recorded all the public schools that existed in March 1903. Following the Education Act of 1857, the School Census recorded every public school that was funded totally or partially with public funds, religious or private charities.[23] Although only public schools were included in this Census, they represented more than 80 percent of

[21] Other variables, such as steam engines per miner, steam horsepower per engine, all engines per mine, or all horsepower per engines, have been used with identical results.

[22] *Censo Escolar de España Llevado a Efecto el Día 7 de Marzo de 1903, Tomo Primero*. Although it was meant to be more volumes with information about teachers or students, this information was never published.

[23] It also includes the schools that were erected by private companies, as a law enacted in 1900 mandated industries to erect and fund schools if there was no easy access to other education facilities for the children of their workers (Ferrer y Rivero 1915, p. 18).

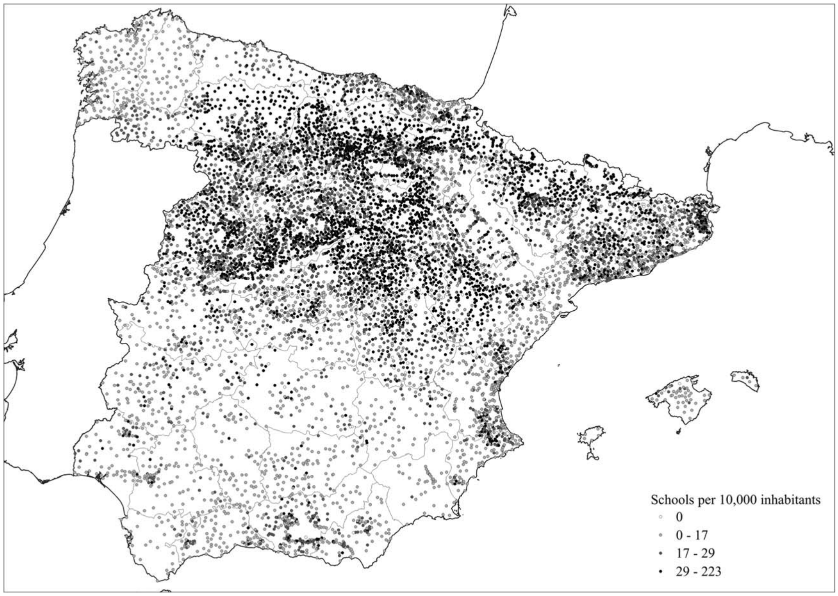

Figure 4. *Schools per 10,000 inhabitants in 1903*

the primary education provision during the period under study.[24] Therefore, this data records the importance, capacity and willingness of Spanish town councils to fund primary education as this institutions were in charge of funding it until 1902.

The information provided by the School Census is completed with the population census of 1900 to obtain the number of schools per 10,000 inhabitants in each Spanish town, depicted in figure 4. There were 279 towns with no schools, mainly concentrated, as the map shows, in north-eastern mountainous regions. Thus, this variable controls for the evolution of the local public provision of education previous to the centralization of primary education, showing the long-term evolution of the supply process developed by municipalities in the previous decades. Therefore, its analysis will reflect how the different mining factors affected local education provision, and the willingness of local authorities to promote education. Additionally, it could indicate the demand from miners to have schools in order to educate themselves or their offspring as the local/regional job market demanded for skilled and educated workers.

Additionally, in order to further analyse the effects on education provision, as the Educational Law of 1857 mandated the number of schools that a municipality should provide according to its population, this measure is used to see whether town councils complied or not with the law. Thus, a dummy variable is created if the municipality had in 1903 the public schools that the Law required, in accordance with its population in 1887.[25] This figure is used instead of the population in 1900 to take into account the time of construction or hiring, as

[24] In 1908, the official Statistics recorded that public schools were 82.7 percent of the total schools in Spain (Anuario Estadístico de España, Año I.-1912, Primera Enseñanza, 1913 pp. 198–199).

[25] Following the requirements in the Education Law of 1857 (Ferrer y Rivero 1915, pp. 255–256), the thresholds are for those towns with less than 500 inhabitants, they comply with the law if they have at least one school, between 500 and 2,000 inhabitants, the number of schools that they had to provide rises to two. Then, every

the number of schools in 1903 would better reflect the reaction from town councils during the years after the 1887 census, than for the census of 1900. By 1903, 80 percent of Spanish municipalities had the schools that were required by law.

3.3. Population census of 1860, 1887, 1900, and 1910

The population censuses provide information on the 9,130 municipalities that existed in Spain from 1860 to 1910. The main variable of interest is the literacy rate, gathered for each municipality and classified by gender, and represents the percentages of individuals who knew how to read and write in the total population of the municipality.[26] In order to determine the real effect and the implications of the mining variables of 1890 on education, and how the provision of schools in 1903 affected human capital formation, I use the literacy rates for 1910. For instance, the high reliance on child labour in a mining basin would not be reflected in the literacy rates of 1887, but rather of 1910, when those children were adults and were reported as illiterate because they had been working in the mines instead of going to school.

Moreover, the literacy rate of 1860 is used to control for potential cultural or institutional influences on education. As indicated in figure 5, which displays the literacy rates for males on the left and the literacy rates for females on the right, there were important differences across regions, and genders, even in the early twentieth century, more than 50 years after the law's implementation.[27] Figures 4 and 5 confirm the need to carry out a subsample analysis, as northern and southern education was significantly different. Given that the impact of the mining sector can be different depending on the underlying education provision and literacy rates, dividing the country by north and south results in a more homogeneous group of towns, and hence provides a deeper understanding of the impact of the mining industry.

As well as indicating the size of the local population, the population censuses provide other relevant information. As was mentioned above, migration likely played an important role in the literacy rates due a positive or negative selection bias of these migrants. Thus, the percentage of migrants, based on the share of the population who were born in another country or province is obtained from the census of 1887, as it was the only one recording this information. Nevertheless, this variable is used to represent the effect of migration flows, even though it is not a perfect measure. Thus, as this variable only controls for those born in another province or country, I include the distance to a provincial or national administrative border. This allows me to differentiate between those towns that had a high share of migrants because they were close to a border, and those towns that attracted migrants for other reasons.

Additionally, in order to overcome the limits of the migration variable, I calculate the population growth using the compound annual growth rate. Consequently, population growth is used to capture the potential pressure that migration and natural population growth exerts on the educational system (i.e., overcrowding schools, etc.). To this end, I compute the growth rate for 1910 and 1900 using the population of 1887 as the base year. Therefore, in

2,000 inhabitants town councils had to provide two extra schools. Thus, a town with a population of between 2,000 and 4,000 must have four schools, a town between 4,000 and 6,000 should provide six schools, etc.

[26] Although a better measure of the literacy rate would not use the whole population (as children too young to attend school are included in our rate), the census does not classify the population by age and literacy at the municipality level.

[27] See Beltrán Tapia et al. (2021) for the regional differences in literacy from 1860 to 1930. The gender gap could be traced back to the gender bias of the Moyano Law of 1857, which reproduced previous laws and conceptions regarding education for girls. See Ballarin Domingo (1989).

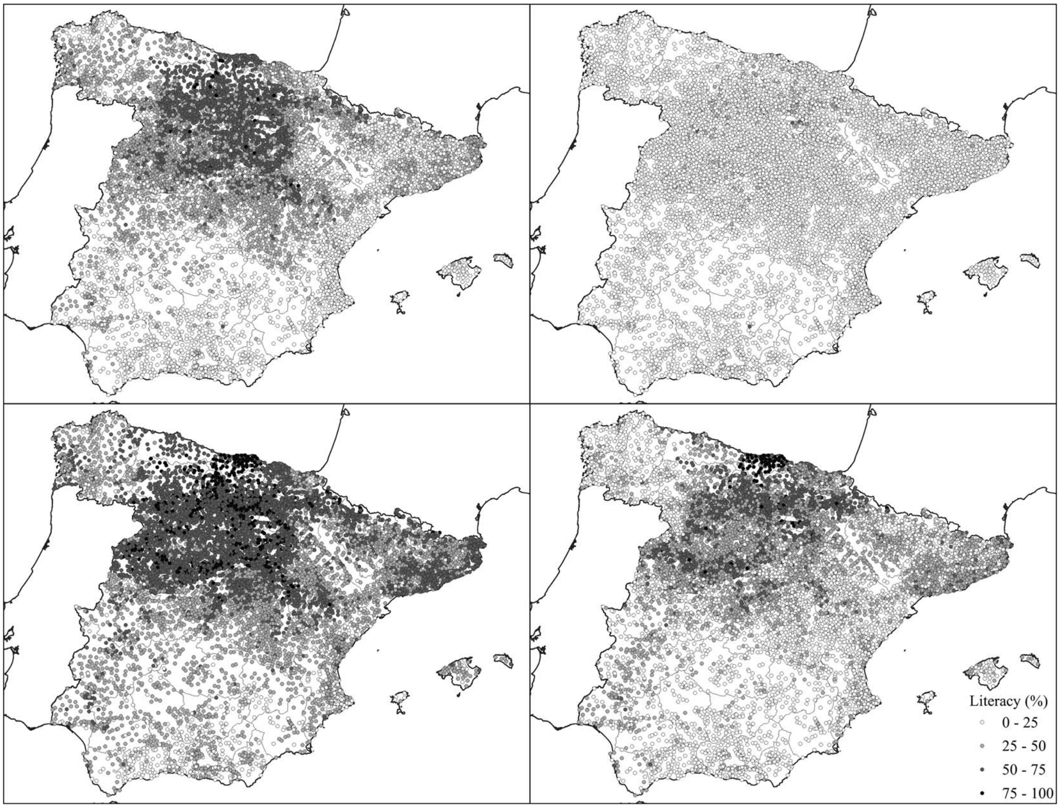

Figure 5. *Literacy rates in 1860 and 1910. Note: The Top maps represent the literacy levels in 1860 of males on the left and females on the right. The bottom maps display the literacy levels of males (left) and females (right) in 1910.*

order to analyse whether mining towns were affected by population growth and migration differently, these two variables have been introduced and interacted with a mining town dummy.

3.4. Descriptive statistics

The descriptive statistics are displayed in tables A.1 and A.2 in the appendix, for the northern and southern samples, respectively. In panel A, the information is presented for all municipalities in the two subsamples; in panels B and C, the same variables are displayed for the non-mining towns and mining towns, respectively.

In the northern municipalities, mining towns had higher female literacy rates in 1860 and 1910, although the male rates and the number of schools were lower than in non-mining towns. In the south, mining towns had similar literacy rates in 1910 as other southern towns, although, in 1860, they started with a slight advantage. However, the provision in southern mining towns was lower, both in schools per capita and in municipalities complying with the Education Law.

The population variables show that in the two regions, mining towns were considerably more populated than the rest of the towns. Similarly, population growth and migration were also higher in mining towns. Nevertheless, northern mining towns had a clearer distinction than their counterparts in the south, which could be due to the fact that their population growth between 1887 and the early twentieth century was seven times higher than non-mining towns. However, in the south, this difference was less pronounced.

Considering the mining variables, with an identical average of miners and horsepower per miner, job market concentration, and presence of foreign companies, southern mining towns presented higher productivity. Moreover, there was a higher incidence of copper and lead mines in the south, and coal and iron in the north, with an important presence of other minerals such as zinc in Cantabria. Finally, as highlighted in figure A.2, child mining labour was more prevalent in the southern mines, while women were more engaged in northern mines.

4. Methodology and results

This section formally assesses the impact of the mining industry on education provision and literacy rates by using the local information presented above.[28] However, due to the high level of spatial correlation of the dependent variables, as can be seen in figures 4 and 5, following Anselin (1988, 2003), the relationship between mining and education has been estimated using a spatial regression model.[29]

The spatial econometric model, therefore, follows this specification:

$$Educ_i = \alpha_i + \beta_{1860} Lit_{Gi1860} + \beta_{Prov} Schools_i + \beta_1 Miners_i + \rho W_D Educ_{i-D} + \beta_X X_i + \epsilon_i \quad (1)$$

$$\epsilon_i = \sigma W_D \mu_{i-D} + v_i \quad (2)$$

Where the dependent variable *Educ* is the number of schools per 10,000 inhabitants in each municipality, or the literacy rate in 1910 for each gender *G*, female and male, depending on the specification. Moreover, the literacy level of 1860, Lit_{Gi1860}, is included to control for historical educational tendencies in the municipality. When the dependent variable is the literacy rate, $\beta_{Prov} Schools_i$, which represents the number of schools per 10,000 inhabitants, is included to control how education provision might affect human capital formation. The influence of the mining industry is captured by the variable Miners, which include the set of mining variables described above. As mentioned above, the Cadastre may underestimate the importance of mines. However, given that these omissions are probably related to the size of the mining sector, the results reported here would underestimate the true effect of mining on education; therefore, this potential underestimation does not constitute a major issue.

Furthermore, this spatial analysis relies on a Spatial Weighted Matrix (W_D), where *D* represents is set in 100 km, following Ashraf and Galor (2011) and Beltrán Tapia and

[28] An OLS model has been used obtaining similar results, although the spatial dependence makes the OLS coefficients not trustworthy.

[29] Assuming the Moran's Index equal to one indicates perfectly geographically clustered values, taking the threshold of 100 km, the Moran's Index for female literacy rates is 0.47, and the values are clustered at the 1percent significance level; and at the same threshold, the Moran's Index for male literacy rates is 0.68, clustered at the 1 percent significance level.

Martinez-Galarraga (2018).[30] In particular, two elements characterize the spatial dimensions of the model. First, the model accounts for the spatial effect (coefficient ρ) that the literacy rates or schools of neighbouring municipalities *i-D* exerted on the literacy rate or schools of municipality i. Finally, this specification also accounts for a spatial error term (coefficient σ), presented in Equation (2), that reflects spatial autocorrelation in the disturbance due to omitted variables.

However, as the variable *Complying with Law* is a dummy variable, the following Logit model must be used, which results are reported in the Appendix:

$$Comply_i = \alpha_i + \beta_{1860} Lit_{Gi1860} + \beta_1 Miners_i + \beta_X X_i + u_i \quad (3)$$

Both specifications also include the following set of control variables (X_i): population, native language, special taxation regime, geographic variables, crops' suitability, and medieval settlement pattern.[31] The control variables used in the econometric models are explained in the appendix, and attempt to control for unobserved factors that are related to both mining and education. Additionally, *Partidos Judiciales* fixed effects (PJFE) are included using these administrative units, which were similar to counties, in order to further mitigate the bias from potential omitted variables.[32] Thus, PJFE will allow me to compare the effects within *Partidos Judiciales*, and thus to give more precise results on the impact of mining on literacy.

[30] I analysed the data with a distance matrix ranging from 25–200 km, and the results were similar to those presented here for 100 km. Results upon request. The W_D is constructed as follows, taking 100 km as D: each municipality (observation) has a row, assuming our matrix with 9,130 rows, each row (municipality) has as many columns as municipalities (observations), again 9,130 columns, thus, our W_D is a 9,130 × 9,130 matrix. As the threshold is set at 100 km, each row/municipality will have each of its columns different from zero if that column (municipality/observation) is within 100 km of that row/municipality, then assuming the value of that column is 1/d, and d is the distance in kilometres. For example, let us say that between Town A and Town B there are 15 km, and between Town A and Town C there are 30 km. The values of the first row (corresponding with Town A) of W_D will be: zero, as between Town A and itself there is no distance; 1/15, as 15 km is the distance between A and B; and zero, as Town C is farther than 100 km away.

[31] Population is included in natural logarithms and is included in order to control for agglomeration economies affecting human capital formation. The native language variable was included following Weber (1976), as education was taught in Spanish, and there were areas in Spain where the native language was not Spanish. For the special taxation variable, as Alonso Olea (1995) has pointed out, the Basque Country and Navarre had a special taxation regime, and they were semi-autonomous of the Spanish state. Following Beltrán Tapia and Martinez-Galarraga (2018), I control for distance to coast as a proxy for a climate variable. As the use of altitude or temperature raised several correlation problems with other variables (railroads), I discarded these geographic controls. Similarly, I use crop suitability in order to control for potential dynamics in the agrarian sector. Finally, as observed in Oto-Peralias (2020), the warfare process during the Medieval period on the Iberian Peninsula affected the settlement patterns, which had long-term effects on economic development in Spain. Moreover, equation (3) includes in the control variables the population groups (from 0 to 500 inhabitants, from 500 to 2,000, and then a group every 2000 inhabitants) instead of the size of population, to analyse municipalities within the same population thresholds established by the Law

[32] See figure A.4 in the appendix for the distribution of *Partidos Judiciales* in Spain.

4.1. Results. Education provision

Table 1, Panels A and B report the results for the northern and southern samples, respectively. Columns (1) to (5) show the spatial analysis for schools per 10,000 inhabitants, with Columns (6) to (10) depicting the same regressions but including PJFE.

In northern mining towns, an interesting result arises in regard to the productivity of mines, as an increase in one standard deviation in productivity would lead to 2.5 more schools per 10,000 inhabitants, or 8 percent more than the average provision. As mines usually implemented piecework payments, a higher value extracted by a miner could be derived in higher salaries. Therefore, these better-paid miners could spend more, or demand more facilities in the town, such as schools. Moreover, as García Gómez (2018) argues, town councils relied mainly on indirect taxes for their revenues, thus, higher productivity and wages could lead to a higher volume of market transactions and higher revenues for the town councils, increasing their capacity to spend on public services such as schools.

However, columns (1) to (3) and (6) to (8) show that the presence of miners had a negative role on education provision, driven by the presence of lead and other mineral mines, as column (10) shows. This indicates that in these mining towns, the unskilled labour-intensive pattern prevailed, with the demand for skilled and educated workers being low. This could have disincentivized town councils to invest in education, as it would have been underused by mining families as education might not have been useful in the job market of those towns, as Humphries (2011, p. 221) argues. Moreover, the higher negative impact was on other minerals, with a 2.1 percent decrease in the number of schools with respect to the average with an increase of one standard deviation. As these mines were few in number and with a low production, this negative role could be linked to the absence of economies of scale and linkages with post-extraction industries, decreasing the demand for skilled labour and the incentives for town councils to increase the number of schools.

Furthermore, the results indicate that in mining towns, there was no discernible difference in the effect on education provision due to migration or population growth. Thus, despite mining towns experiencing significantly higher population growth, as Pérez-Fuentes Hernández (2004) finds for Biscay, this influx of migrants and natural growth does not appear to have affected education provision.

The results in Panel B show a different picture for southern mining towns. The mining sector did not affect, either positively or negatively, the provision of public schools. Only steam engines and female labour in mines had a statistically significant effect. Concerning the former, the demand for educational facilities to train workers capable of operating the engines might have motivated southern town councils to invest in education. Regarding the latter, as women could be engaged in mining tasks from a young age, lower demand for school spots from these girls could discourage town councils from investing in education.

In comparison with the results for the north, this indicates a failure of southern mining towns to take advantage of the mining wealth to transform it into a better education provision, even with a productivity that was 200 *pesetas* higher than the northern mines. This was especially relevant as school provision in southern mining towns was almost a third of the provision in the north. Nevertheless, the regressions for the compliance with the law, presented in the Appendix, table A.3, show that the mining sector had effects on this variable. Whereas towns with no mines had a probability of complying with the law of around 50 percent, in towns where 2.5 percent of the population worked in copper mines, the probability of having the required amount of schools fell to 35.4 percent. However, having 2.5 percent of the population working in iron mines would mean a probability of five more percentage

Table 1. *Education Provision*

Panel A. North	Schools per 10,000 inhabitants									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Miners (%)	−0.253***	−0.253***	−0.207**			−0.215**	−0.223**	−0.206**		
	(0.091)	(0.089)	(0.089)			(0.091)	(0.092)	(0.099)		
Productivity	0.290*	0.267*	0.294**	0.288*	0.332**	0.333**	0.289**	0.299**	0.328**	0.422***
	(0.153)	(0.138)	(0.130)	(0.159)	(0.157)	(0.138)	(0.138)	(0.137)	(0.159)	(0.155)
Mining town (dummy)	5.311***	7.092***	6.458*	6.215***	8.775*	4.495**	5.569**	4.808	5.320***	6.661
	(1.850)	(2.498)	(3.748)	(1.851)	(4.730)	(1.760)	(2.408)	(3.853)	(1.725)	(4.875)
Mining town*Pop. growth	1.160				0.942	1.043				0.749
	(0.739)				(0.771)	(0.721)				(0.708)
Mining town*Migration	−0.081				−0.141	−0.127				−0.232*
	(0.105)				(0.122)	(0.107)				(0.125)
Steam hp per miner		−1.646*			−1.086		1.221			0.831
		(0.848)			(0.955)		(1.343)			(1.400)
Percent female labour		−0.164			−0.135		−0.057			−0.020
		(0.107)			(0.097)		(0.119)			(0.105)
Percent child labour		−0.053			−0.077		−0.086			−0.102
		(0.110)			(0.116)		(0.103)			(0.109)
Percent miners in foreign companies			−5.893**		−4.769*			−0.504		−0.823
			(2.346)		(2.697)			(2.710)		(3.056)
Mining property			−0.089		−0.120			−0.338		0.412
			(2.117)		(2.138)			(2.096)		(2.081)
Copper miners (%)				−0.813	−1.035				−2.396	−2.730*
				(1.979)	(1.990)				(1.577)	(1.558)
Coal miners (%)				−0.170**	−0.117**				−0.152*	−0.123
				(0.066)	(0.058)				(0.083)	(0.084)
Iron miners (%)				−0.192	−0.192				−0.130	−0.130
				(0.141)	(0.122)				(0.141)	(0.123)
Lead miners (%)				−1.165***	−0.870***				−0.938***	−0.753**
				(0.167)	(0.187)				(0.255)	(0.359)
Other minerals miners (%)		−0.903***	−0.876**			−1.080**	−1.098**	−1.098**		
		(0.336)	(0.386)				(0.455)	(0.429)		
Observations	3679	3679	3679	3679	3679	3679	3679	3679	3679	3679
Pseudo R2	0.359	0.360	0.360	0.357	0.360	0.389	0.390	0.388	0.390	0.388

(Continued)

Table 1. *Continued*

Panel B. South	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Miners (%)	−0.050	−0.004	0.016			0.229	−0.064	−0.065		
	(0.056)	(0.045)	(0.051)			(0.172)	(0.058)	(0.058)		
Productivity	−0.022	−0.025	−0.020	−0.010	−0.007	0.025	−0.017	−0.023	−0.010	−0.007
	(0.021)	(0.033)	(0.030)	(0.041)	(0.031)	(0.053)	(0.033)	(0.035)	(0.038)	(0.034)
Mining town (dummy)	1.432*	0.905	3.018**	2.040***	1.282	−1.062	1.971*	2.150	1.422	1.573
	(0.752)	(0.941)	(1.328)	(0.695)	(1.474)	(1.518)	(1.038)	(1.331)	(0.946)	(1.385)
Mining town*Pop. growth	0.768**				0.658	0.139				0.157
	(0.381)				(0.440)	(0.593)				(0.431)
Mining town*Migration	0.108				0.163	0.230				0.070
	(0.092)				(0.100)	(0.166)				(0.103)
Steam hp per miner		1.324			0.480		1.823*			1.800*
		(1.172)			(1.108)		(1.015)			(1.003)
Percent female labour		−0.082*			−0.046		−0.140**			−0.156***
		(0.046)			(0.050)		(0.055)			(0.060)
Percent child labour		0.086*			0.085*		0.018			0.024
		(0.045)			(0.046)		(0.045)			(0.039)
Percent miners in foreign companies			−0.105		−0.290			2.723		1.727
			(1.466)		(1.399)			(1.685)		(1.332)
Mining property			−0.601		−0.934			−0.122		−0.393
			(0.865)		(0.831)			(0.838)		(0.751)
Copper miners (%)				−0.037	−0.069*				−0.054	−0.092
				(0.035)	(0.042)				(0.103)	(0.063)
Coal miners (%)				0.050	−0.144				0.082	0.000
				(0.150)	(0.157)				(0.207)	(0.160)
Iron miners (%)				0.338**	0.269				0.188	0.229
				(0.148)	(0.194)				(0.232)	(0.171)
Lead miners (%)				0.051	−0.098				−0.038	−0.066
				(0.126)	(0.145)				(0.199)	(0.146)
Other minerals miners (%)				−0.547**	−0.561**				−0.368	−0.351
				(0.232)	(0.228)				(0.341)	(0.335)
Controls/spatial lags	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Partido Judicial FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	1701	1701	1701	1701	1701	1701	1701	1701	1701	1701
Pseudo R2	0.544	0.543	0.543	0.543	0.545	0.496	0.566	0.558	0.518	0.581

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

points than a non-mining town. This could indicate that there were different incentives for town councils to comply with the law regarding these two minerals. For instance, in iron mines, there could have been a demand for educated workers for the mines or post-extraction processes, whereas in southern copper mines there was no such demand, disincentivizing town councils to invest in education. However, the presence of private schools could have reduced the need for public provision, as in these towns human capital was fostered by the copper mines, as we shall see in the next section.

In conclusion, the mining sector was able to affect education provision. In line with the findings of Maurer (2019) or Montalbo (2020), and although there was a general negative effect of mines on education provision, more productive northern mining towns could transform their mining wealth into more educational facilities, which would enhance human capital formation, or at least the access to it. Nevertheless, in some northern mining towns, and in the south, mineral capital did not foster education provision. Escudero et al. (2019) identified the control that the mining owners had of local politics to explain the delay of public service provision in southern mining towns. However, the results shown here do not indicate foreign companies or a highly concentrated ownership of mines or population growth to explain the lower numbers of schools. The results seem to point to the different job market patterns established around the mines, the industrial linkages, and the demand for skilled workers that different minerals had on education. Additionally, productivity and technology usage, and consequently the need for educational infrastructure by the population, played a significant role.

4.2. Results. Literacy rates

Table 2, Panels A and B depict the results of the spatial regression for northern and southern male and female literacy rates, including PJFE. For northern towns, although there is a negative effect of the Mining town dummy on both male and female literacy rates, it is only statistically significant in columns (4), (8), and (10), which cast doubts on its statistical relevance. Regarding the use of technology in mines, steam horsepower per miner had a significant positive effect on human capital formation, although with only a clear effect on men. As steam horsepower per miner did not affect school provision, following Mokyr et al. (2019), the intensive use of steam engines could be related to a higher degree of skills requirements in the local job market to either install or repair steam engines. This, together with a higher investment in capital in these mines and potential connections with post-extraction industries, could have fostered the demand for skilled and educated workers, incentivizing families to invest in their boys' education. Moreover, copper mines had a positive effect on both male and female literacy rates in the north, although clearer on men's education. This might indicate that in these towns, the local job markets demanded educated workers as there might be post-extraction linkages, prompting families to invest in their children's education.

Furthermore, the concentration of mine ownership positively affects women's education. This result may seem counterintuitive, as higher concentration would imply lower bargaining power for miners and potentially lower wages, given that there might be only one or two mining companies in the basin. However, higher concentration could indicate more modern mining companies, in contrast to traditional mining characterized by crews with family ties temporarily hired in different mines in the same basin. Thus, more modern mining companies could be hiring fewer women, as the modernization of the sector reflected for the late nineteenth and early twentieth centuries (Pérez de Perceval Verde et al. 2020), enabling them

Table 2. *Literacy Rates with Partido Judicial FE*

Panel A. North	Males					Females				
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Miners (%)	−0.062	−0.051	−0.079			−0.194**	−0.190**	−0.228***		
	(0.057)	(0.058)	(0.057)			(0.078)	(0.078)	(0.083)		
Productivity	0.018	0.042	0.040	0.051	−0.000	0.218*	0.192	0.207*	0.216	0.209
	(0.084)	(0.073)	(0.073)	(0.082)	(0.085)	(0.130)	(0.121)	(0.125)	(0.143)	(0.148)
Mining town (dummy)	−0.358	−1.015	−1.855	−0.608	−3.594**	−0.929	−0.834	−5.960**	−0.985	−6.384*
	(1.075)	(1.307)	(1.465)	(0.994)	(1.814)	(1.652)	(1.966)	(2.919)	(1.634)	(3.361)
Mining town*Pop. growth	0.138				0.281	0.837				0.963
	(0.487)				(0.521)	(0.740)				(0.777)
Mining town*Migration	0.032				0.125	−0.075				0.009
	(0.066)				(0.081)	(0.081)				(0.094)
Steam hp per miner		2.598***			2.023***		3.141**			2.275
		(0.781)			(0.774)		(1.462)			(1.688)
Percent female labour		0.124*			0.085		0.093			0.050
		(0.075)			(0.064)		(0.118)			(0.099)
Percent child labour		−0.000			0.028		−0.054			−0.042
		(0.053)			(0.056)		(0.102)			(0.100)
Percent miners in foreign			2.535		2.070			2.233		2.112
companies			(1.994)		(1.824)			(3.288)		(3.618)
Mining property			0.906		0.887			3.429**		3.334**
			(0.852)		(0.879)			(1.670)		(1.679)
Copper miners (%)				0.836**	0.946**				1.336*	1.299*
				(0.382)	(0.408)				(0.775)	(0.752)
Coal miners (%)				−0.027	−0.050				−0.114	−0.133
				(0.054)	(0.057)				(0.080)	(0.085)
Iron miners (%)				−0.057	−0.137				−0.291**	−0.381***
				(0.097)	(0.116)				(0.116)	(0.135)
Lead miners (%)				−0.177	−0.310				−0.263	−0.459
				(0.495)	(0.452)				(0.565)	(0.586)
Other minerals miners (%)				0.173	0.172				−0.240	−0.321
				(0.166)	(0.160)				(0.290)	(0.291)
Observations	3679	3679	3679	3679	3679	3679	3679	3679	3679	3679
Pseudo R2	0.589	0.589	0.589	0.590	0.590	0.503	0.504	0.504	0.504	0.505

(Continued)

Table 2. *Continued*

Panel B. South	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Miners (%)	0.116	0.128**	0.202***			0.182	0.106	0.051		
	(0.080)	(0.063)	(0.055)			(0.121)	(0.088)	(0.120)		
Productivity	−0.018	−0.023	0.009	0.017	−0.009	−0.020	−0.037	−0.054	−0.084***	−0.064***
	(0.052)	(0.044)	(0.043)	(0.067)	(0.024)	(0.050)	(0.031)	(0.049)	(0.029)	(0.021)
Mining town (dummy)	−0.117	−0.175	−0.497	−2.212	−0.285	−0.949	−1.280	−2.686	−0.980	−1.983
	(1.541)	(1.211)	(1.457)	(2.219)	(1.764)	(1.251)	(1.062)	(1.777)	(0.766)	(1.326)
Mining town*Pop. growth	0.111				0.371	−0.156				−0.007
	(0.728)				(0.446)	(0.651)				(0.394)
Mining town*Migration	−0.218				0.012	−0.281				−0.032
	(0.410)				(0.111)	(0.214)				(0.085)
Steam hp per miner		−0.437			−0.434		1.336			0.570
		(1.601)			(1.593)		(1.453)			(1.152)
Percent female labour		0.144			0.226*		0.036			0.075
		(0.120)			(0.116)		(0.085)			(0.088)
Percent child labour		−0.053			−0.045		−0.005			0.001
		(0.054)			(0.054)		(0.050)			(0.047)
Percent miners in foreign companies			−4.502**		−3.722*			−3.671		−1.034
			(1.991)		(2.039)			(2.289)		(1.532)
Mining property			0.174		0.213			1.118		0.679
			(0.977)		(1.027)			(1.253)		(0.855)
Copper miners (%)				0.293**	0.227***				0.083	0.129**
				(0.119)	(0.065)				(0.073)	(0.059)
Coal miners (%)				0.542	0.072				−0.450***	−0.322**
				(0.550)	(0.186)				(0.127)	(0.135)
Iron miners (%)				0.454	0.063				0.104	0.133
				(0.591)	(0.139)				(0.121)	(0.129)
Lead miners (%)				0.347	0.044				0.048	0.061
				(0.265)	(0.155)				(0.123)	(0.131)
Other minerals miners (%)				1.018**	0.609				0.870***	0.872***
				(0.510)	(0.443)				(0.295)	(0.277)
Controls/spatial lags	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1701	1701	1701	1701	1701	1701	1701	1701	1701	1701
Pseudo R2	0.312	0.511	0.483	0.482	0.523	0.272	0.398	0.400	0.413	0.450

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

to attend school if not needed for minor mining tasks. Moreover, the concentration could indicate more stability in the local mining job market. For instance, companies like Minas de Rio Tinto or Orconera Iron Company operated mines from the late nineteenth century to the Spanish Civil War in the same towns in Huelva and Biscay, respectively. This continuity in employment could provide job stability and opportunities for career development for miners, thereby making it possible to afford girls' education for mining families.

Moreover, the negative effect seen in iron mines for women confirms what the literature finds for these mines in northern Spain (see for instance Pérez-Fuentes Hernández 2004). In the case of iron mines, women were not present at the mines, but as the male breadwinner model was extended in these northern mines, women were usually engaged in informal tasks to complement the men's salaries. Thus, young girls were usually responsible of minor tasks that prevented them from attending school. Furthermore, as Palacios-Mateo (2023) argues, in these iron mines, low wages were prevalent, which led to a concentration of the scarce resources of mining families on boys' education, as they would have higher education returns in the job market. Nevertheless, it should be taken into account that schools are included in the regressions of table 2. Therefore, besides the impact of a lower provision of schools in these towns seen in table 1, the negative effect observed in female education came from the demand side.[33]

Panel B shows a different picture in southern mining towns. Unlike the absence of an effect in northern towns, in the south, productivity had a significant negative impact on female education when the percentage of miners is introduced by mineral. As argued above, as piecework was common, higher values could reflect higher payments, and therefore families might have wanted to engage more family members in the mines. Therefore, women would have been employed in different tasks to maximize the benefits, which, in turn, impeded the schooling of girls. Additionally, a negative effect of coal mines can also be observed for southern females, an impact that may be associated with comparable household patterns observed in iron mines in the northern mining region.

Furthermore, the positive impact of miners, as observed in columns (2) and (3), originates from copper and other mineral mines. This outcome, mirrored in female literacy in column (10), indicates that despite the absence of effects of mines on education provision in the southern region, both men and women were able to access education. This suggests that, as a positive migration bias can be ruled out due to its lack of statistical significance, families prioritized education for their children despite the limited availability of public schools. It is plausible that they opted for private schooling, driven by incentives from the local job market to invest in education.

Finally, the presence of foreign mining companies had a negative effect on male literacy rates, although relatively small, as an increase in one standard deviation was reflected in a decrease of 1.2 percent in male literacy rates. This may indicate that, as top-ranking jobs were filled with foreign workers (engineers, administrators . . .), families could have had less incentives to invest in boys' education, as there were lower returns on the education investment.

In conclusion, the industry had mixed effects on human capital formation. In both regions, capital investment and linkages with post-extraction industries could have been behind the positive effect observed for steam engines and in copper mines. However, despite this

[33] When schools per 10,000 inhabitants are excluded from the regression, the negative effect on northern female rates remains significant and negative. Results upon request.

transformative effect, either the direct or indirect involvement of women in the sector led to a decrease in their education. Palacios-Mateo (2023) stresses that Spanish mining families, facing scarce resources, prioritized their sons' education over that of their daughters, as men would have higher educational returns in the job market than women. This allowed boys to have a similar literacy level as boys in other working-class families, while girls in mining families had a significantly lower literacy level than in any other socio-economic group. This is in line with the results presented here as the mining sector significantly hampered female literacy in both regions, while there were no important negative effects on males.

5. Conclusion

This study seeks to shed some light on the dynamics between the mining sector and human capital from a historical perspective. The results show that in some mines, the capital investment in modern technology, higher productivity or linkages with post-extraction industries generated a demand for skilled workers in the local job markets that stimulated education. Following the literature that finds a link between mineral wealth and industrialization, such as Domenech (2008), Gutberlet (2014), or Fernihough and O'Rourke (2021), this paper stresses that it might be the link between mineral wealth, industrialization/modernization and the demand for educated workers that could prompt human capital formation in some mining towns.

However, in other mining towns, such as those where lead, tin, or nickel were extracted, the results indicate that the labour-intensive use of unskilled workers was hampering education, as educated workers were not demanded in these municipalities. Therefore, as Mitch (1992), Humphries (2011), or Palacios-Mateo (2023), among others, point out, in these mining towns, the unskilled requirements and the low living standards might be prevalent, which led to a lower demand for education from families and a passive attitude from town councils. This effect was particularly acute for women, as their engagement in coal and iron mining towns had an important negative effect on their human capital formation. This might indicate that there was a need for extra income in mining families and, therefore, a preference to educate boys instead of girls in these towns. This is especially relevant as, during the early twentieth century, female literacy rates significantly increased, indicating the results here presented that the mining sector acted in the opposite direction.

Thus, this paper shows that some mining towns were able to transform their mineral wealth into human capital, and therefore contribute to the educational process that took place in Spain during the period under study. However, low living standards or an absence of a linkage with other industries prevented either families or town councils from investing in education, especially for women. Therefore, two aspects should be addressed in further research. First, as Section 2 shows, the mining boom was more intense between 1900 and 1920. Therefore, an exploration on the role of the sector during this period should be conducted to corroborate the results found in this study. Second, following Franck and Galor (2021), a deeper understanding of the long-term effect of the mining sector is required. For instance, as mines were depleted, were institutions able to transform the local economy, or did these towns stagnate or lag behind as mineral wealth disappeared?

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Data availability

The data for the Schools in 1903 and the Mining Cadastre of 1890 underlying this article are available at *Biblioteca Nacional de España*, signature 1/41203, and *Estadísticas Mineras* 1890–1891 respectively. Regarding the literacy rates, the data was provided by the Economic History Group of the Universitat de València.

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Supplementary material

Supplementary material is available at *European Review of Economic History* online.

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