Education and economic development. The influence of primary schooling on municipalities in nineteenth-century France

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WORKING PAPER N° 2019 – 50

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September 4, 2019

Abstract

The impact of education on growth or individual earnings has been vastly studied in economics. However, much remains to know about this association before the mid-20th century. In this article, I investigate the effect of primary schooling on the economic development of French municipalities during the 19th century and up to World War I. Before the Guizot Law of 1833, no national legislation on primary schooling existed in France. Therefore, I evaluate if the municipalities with higher educational achievements before this law grew more than their counterparts during the following years. To do so, I exploit first the fact that the Guizot Law forced municipalities over 500 inhabitants to open and fund a primary school for boys. I implement a regression discontinuity around this cut-off on municipalities with no primary school in 1833. Second, I instrument educational achievement, namely enrolment rates and schooling years, by the proximity of municipalities to printing presses established before 1500. Each method returns a positive impact of education on development. Education quality also mattered in this perspective. A matching estimation on municipalities with a school in 1833 indicates a positive impact of better teaching conditions provided by public grants on the subsequent growth of municipalities. Primary schooling is therefore an important factor which favoured the development of French municipalities during the century of industrialisation and modernisation.

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†I am grateful to Jerôme Bourdieu, Lionel Kesztenbaum, Eric Maurin and Quentin Lippman for helpful comments. I would like to thank Anne-Marie Chartier and André Oliva for helping me access the archives and sharing data on the Guizot Survey.

1 Introduction

The contribution of human capital to economic growth is an ongoing and debated topic. Theoretically, education has been analysed as a potential driver of long-term sustained growth in the endogenous growth literature [Lucas, 1988], [Romer, 1990], or as a mere factor of production in neo-classical models [Mankiw et al., 1992][1]. Empirically, there also has been a debate on whether the level or the change in education would impact growth. Early studies, in line with the endogenous growth literature, found a positive influence of educational levels and not changes [Romer, 1990], [Benhabib and Spiegel, 1994]. However, they have been criticised on the basis of measurement errors in education which could impact more strongly changes in variables than levels [Krueger and Lindahl, 2001]. More recent studies have identified a positive link between both the level and the changes in education with economic growth [Gemmell, 1996], [Krueger and Lindahl, 2001]. Finally, improving the original Barro-Lee data on schooling years [Barro and Lee, 1993] had led scholars to conclude about a positive and significant impact of changes in education [de la Fuente and Doménech, 2006], [Cohen and Soto, 2007], [Ciccone and Papaioannou, 2009]. These studies focused on the 1960-2000 time period, using country-level data in a macroeconomic setting[2].

Another branch of the literature focused rather on the impact of education on individual earnings at the micro level. From the early work of Mincer [Mincer, 1958], [Mincer, 1974], it has been shown than the return to one additional year of education was lying between 6 and 10%, depending on the estimation strategy adopted. Instrumental variable estimations, using either the unequal access to education [Angrist and Krueger, 1991], [Angrist and Krueger, 1992], [Card, 1993] or a comparison between twins [Ashenfelter and Krueger, 1994], [Miller et al., 1995], [Ashenfelter and Rouse, 1998], [Isacsson, 1999] have been used to this end[3]. This literature also focused mostly on the post-World War II era and, to a lesser extent, on the early 20th century [Goldin and Katz, 2000].

In this paper, I evaluate the contribution of education to economic development in nineteenth-century France and until Word War I. Compared to most of the existing studies, I adopt a long-term historical perspective to evaluate the relation between instruction and growth. I also focus on a century marked by major economic changes, industrialisation and modernisation. Primary schooling is the level of education under scrutiny in this work. Up to the Guizot Law of 1833, there was no strong national supervision of primary schools in France. Teachers could almost freely settle in any municipality and start practising. In this context, primary instruction developed quite heterogeneously over the French lands, with a clear educational advantage for the regions located north of a line going from St-Malo to Geneva [Dupin, 1826]. But did this make a difference in terms of economic growth ? And if so, how large was the

[1] See also [Azariadis and Drazen, 1990] for an elaboration of the Diamond model.

[2] The positive and significant impact of education on growth has been more deeply questioned in other studies pointing out its potentially over-estimated impact [Klenow and Bils, 2000], [Pritchett, 2001].

[3] Discontinuities in mandatory schooling years have also been used to measure the returns to education [Harmon and Walker, 1995]. See [Card, 1999] or [Ashenfelter et al., 1999] for a literature review on returns to schooling.

association between education and development ? I focus on primary schooling since only half of the men were literate in France at the beginning of the 19th century, and less than one-third of the women. It is at this level that a strong convergence took place during this century, with a mass movement of increase in literacy. Therefore, it is interesting to evaluate how primary education interacted with economic development during the 19th century.
To explore these questions, I focus at the disaggregated level of municipalities, using a newly constituted database collected just before the passing of the Guizot Law. These data cover 22 departments and more than 8 000 municipalities. Therefore, I don't compute individual returns to schooling, nor growth rates at the more aggregated level of departments. What I am mainly interested in is to evaluate if an early investment in primary schooling at the municipal level (therefore before 1833) had an impact on the subsequent development of these very municipalities. The amount of taxes per capita collected in municipalities in 1881 and 1911 is the measure used to approximate their economic resources and development. As a consequence, this work lies between the micro and macro-level studies on human capital and is methodologically close to urban economics articles focusing on the impact of human capital on the population and economic growth of cities [Glaeser et al., 1995], [Simon and Nardinelli, 2002], [Glaeser, 2003], [Glaeser et al., 2004].

I make use of different estimation strategies to link primary education to economic development. First, I use a feature of the Guizot Law to implement a regression discontinuity. The law made mandatory for each municipality more than 500 inhabitants to open and fun a primary school for boys. I therefore select municipalities without primary schools in 1833 close to this population cut-off to investigate the impact of education on economic resources. I find a positive effect, with a magnitude close to 2 francs per capita. This corresponds to around one-third of a standard deviation in municipal resources.
These outcomes are complemented and supported by an instrumental variable (IV) strategy. Primary schooling achievements were higher in the north-eastern part of France, close to the city of Mainz where the printing press was first introduced by Johannes Gutenberg around 1450. The distance to this city has already been used to instrument primary schooling expansion [Diebolt et al., 2017b]. In this work, I select two different instruments, the distance between municipalities and the nearest printing press established in 1500, along with the number of printing presses in 1500 within a given radius around municipalities (100 kms most of the times). I find a strong association between them, enrolment rates and the average schooling years within primary schools. There is no significant relation between the printing press and the previous population growth of municipalities, taken as a proxy for economic development, or their industrial and postal characteristics around 1840. The same is true for the relation between the press and the economic resources of departments in the early 19th century. I explain more deeply in the paper why these results are not at odds with [Dittmar, 2011]. This strategy exhibits a strong and positive link between schooling years, enrolment rates and the economic resources of municipalities. One additional year of schooling in a given municipality was associated with a 15% increase in economic resources at the end of the century. A one-

percent increase in enrolment with a 0.4% increase in resources. These two measures can be taken as fairly good proxies for human capital accumulation in the early nineteenth-century France [Montalbo, 2019].

Finally, in relation with the recent literature about the impact of schools' and teachers' quality on education and development [Hanushek, 2011], [Hanushek and Woessmann, 2008], I use a matching estimation to explore the effect of primary schooling quality. I find a positive association between the financial stability provided to teachers by municipal investment in education and the subsequent level of economics resources. Teachers' level of certification was however not significantly linked to development when controlling by enrolment and schooling years.

In this paper, I also discuss the potential transmission channels between education and economic development during the nineteenth century. More jobs were requiring to master at least literacy during its second part, which can explain part of this association. Also, the diffusion of technological progress may have been faster in municipalities where education was more developed, especially in the agricultural sector. Lastly, primary schooling may have attracted people with a higher preference for education. These migrations might therefore have in turn reinforced the positive effect of instruction on workers' productivity by increasing the share of educated people within a given municipality.

This article contributes to the literature on human capital by investigating its association with economic development in the age of industrialisation and modernisation. Indeed, the 19th century, and especially its second part, was characterised by a surge in industrial activities in France. Moreover, the agricultural sector saw its apogee at that time before it entered a phase of crisis from the 1880s to the World War I [Duby and Wallon, 1976]. This paper is therefore directly linked to studies which found a positive association between education and growth in the pre-industrial era [Cipolla, 1969], [de Pleijt, 2018]. High educational achievements have notably been associated to the Little Divergence between England, the Low Countries and the rest of Europe over the 1300-1800 time period [Baten and van Zanden, 2008], [de Pleijt and Zanden, 2016][4]. The association is however not valid for all European countries [Sandberg, 1979]. In the case of France, [Squicciarini and Voigtländer, 2015] also show a positive effect of upper-tail knowledge on city growth and industrial performance during the onset of industrialisation.

However, these articles focus on the pre-19th century period and mostly on upper-tail knowledge without providing a measure of primary schooling achievement. Literacy rates taken as a proxy for schooling are therefore often found not to have been significantly linked to growth over the period under scrutiny. This paper sheds a new light on a potential missing factor which contributed to the growth of municipalities during the era of modernisation, namely primary education. It is therefore close to development economics articles focusing on the recent contribution of primary schooling to growth and earnings[5].

The next section presents some historical facts about primary schooling and economic devel-

[4]See also [van Lottum and van Zanden, 2014] on the importance of skills in the maritime sector before the industrialisation.

[5]See for example [Duflo, 2001] or [Glewwe and Jacoby, 2004].

opment in nineteenth-century France. Section 3 is a description of the data I use while Section 4 presents the results from the regression discontinuity design approach. Instrumental variable outcomes are presented in Section 5 while the influence of education quality on economic development is studied in Section 6. In Section 7, I discuss the potential transmission channels between primary education and economic development. Section 8 concludes.

2 Primary Education and Economic Development Over the Century

The Guizot Law was passed on the 28th of June 1833, making compulsory for any municipality over 500 inhabitants to open and maintain a primary school for boys. Teachers were also to be paid on a regular basis, not less than 200 francs a year. This law was the first major step towards universal schooling undertaken in France. To this date, the decision to open a primary school (along with paying the teacher on a fixed basis or not, how much, buying books, blackboards and other pieces of furniture, providing the teacher with an accommodation or a classroom,...) was mainly made at the level of municipalities[6]. Local authorities thus played an important role, along with parents who were in most cases (except when they were listed as indigents by the municipality or when the school was totally free, which was extremely rare at that time) paying fees so that their children could attend school. Before the passing of the law, primary schools were divided into two types. Those only financed by the monthly tuition fees paid by families to the teachers were said to be private. When municipalities were investing in schools, by paying teachers or providing them with a classroom or an accommodation for example, the schools were said to be public.

In this context, primary schooling developed differentially across regions [Kennedy and Netter, 1981]. From the early work of the Dupin baron, an opposition has been drawn between a well-educated France above the Saint-Malo/Geneva line and a less-educated one below [Dupin, 1826]. For example, in the 1820s, the enrolment per 100 children six to thirteen years of age was higher north of the line, with a mean of 94, compared to south of it, with an average level of 53. This was also true for the schooling of girls [Grew and Harrigan, 1991]. Figure 1 depicts this distinction between French departments. Therefore, before the Guizot Law, primary schools and high enrolment rates were mostly concentrated in the north-east part of France, even if some other regions as the Rhône Valley and the Gironde were also characterised by rather good schooling levels. This pattern remained stable at least until the 1860s in France, even if a convergence in educational attainment was already at work before the Ferry Laws of 1881-

[6] A precise description of the daily life of schools and teachers in the eighteenth and early nineteenth centuries can be found in [Duveau, 1957]. Analyses or testimonies on the state of primary schooling by teachers from the early nineteenth century are available in [Lorain, 1837] and [Meunier, 1981]. In order to have an analysis of local schooling development in the eighteenth century, see for example [Vovelle, 1975] or [Laget, 1971]. See [Gildea, 1983] for a local study from 1800 onwards for the departments of Ille-et-Vilaine, Gard and Nord. In order to have a full political analysis and a description of the laws, projects, and debates about primary instruction during this period of time, one can refer to [Gontard, 1959], [Mayeur, 2004] and the second and third chapters in [Furet and Ozouf, 1977a].

1882 [Diebolt et al., 2005], which made primary schooling compulsory. The number of children schooled per 10 000 inhabitants, for example, still followed closely the geographical distribution described in the mid-1850s and mid-1860s. The same is true for percentage of women or men signing their marriage license in 1871-1875.

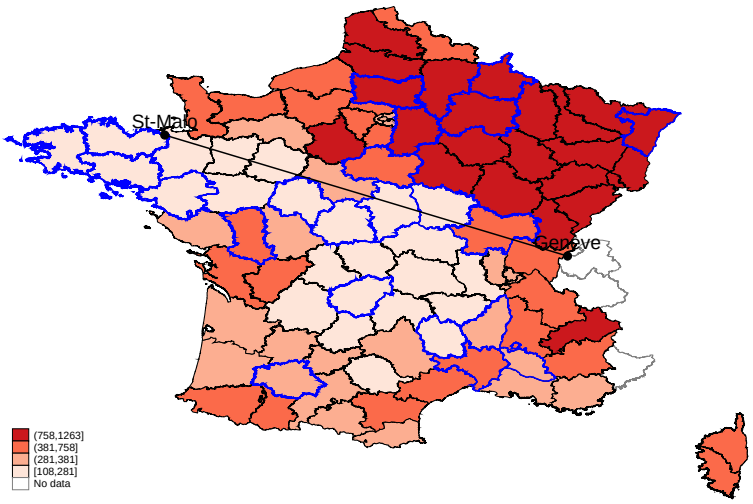


Figure 1: Number of pupils attending primary schools - winter 1833 (over 10 000 inhabitants)

Source: [Motte et al., 2003], Guizot survey - Report to the King.
Note: Departments in blue are the ones for which education data are available at the level of municipalities.

The schooling of girls followed a different path as, until late into the 19th century, numerous religious congregations were in charge the schooling of girls. For example, the *Ursulines* in the south-east, the *Filles de Notre-Dame*, the *Sœurs de la Charité de l'instruction chrétienne* or the *Filles de la Visitation* within the Parisian region [Mayeur, 2004]. But for the majority of them, no education was provided outside of the family sphere. They were not supposed to be taught along with boys within primary schools. However, it was common to gather both sexes when economic resources were too scarce to create two distinct schools[7]. It is only with the Falloux Law of 1850 that the opening of a primary school for girls in municipalities more than 800 inhabitants was made compulsory. The Duruy Law of 1867 lowered the threshold to 500 inhabitants. The Ferry Laws then applied to girls too.

The nineteenth century was, for most Western countries, a period of economic modernisation and growth. Industrial production began to grow substantially from 1815 onwards in France, with an annual rate of 3% for the best years [Lévy-Leboyer, 1968] compared to around 0.5% between 1781-1790 and 1803-1812 [Crouzet, 1996]. The highest rates were attained at the end of the July Monarchy and under the Second Empire. They subsequently dropped below their average value over the century after 1882 [Crouzet, 1970]. This growth remained however

[7] At the time of the passing of the Guizot Law, separated primary schools for girls were still rare. Victor Cousin described them as "almost luxury schools" before the Chamber of Deputies in 1833.

quite gradual all over the century, which led some authors to deny the idea of a real industrial take-off in France [Mendels, 1972][8]. According to the Industrial survey of 1861-1865, textile and food industries were clearly the leading sectors even in the second part of the century. They represented respectively 31.4% and 20.8% of industrial value-added, against around 6% for extractive industries and 5% for the metallurgy [Verley, 1997][9].

The geography of industrial activities also evolved during this century. Data from the 1839-1847 Industrial survey show that manufactures were mostly concentrated in the north-west and western departments close to the Atlantic Ocean in the first part of the century. This concentration was associated to the volume of commercial activities in Atlantic ports like Le Havre, La Rochelle or Nantes [Asselain, 1984]. Big manufactures and steam engines were on the contrary more concentrated in the north and north-eastern parts of France, along with the Rhône Valley. This was associated to the progressive surge of mining and metallurgic sectors in France at that time, in particular to the exploitation of coal and iron. Deposits were indeed highly concentrated in the Nord-Pas-de-Calais, Lorraine, Auvergne, Loire, Dauphiné, Provence and Cévennes areas in France. In some regions as Normandie or the Dauphiné, the concomitant presence of rivers, forests and deposits explains the ancient presence of metallurgic sectors [Léon, 1948], [Richard, 1962], [Kellenbenz, 1963]. Textile activities also followed closely this geographical pattern [Dunham, 1953].

Industrial activities were negatively affected by a general downturn towards the end of the century as the 1880s were particularly bad for French economy. Rural industry was severely altered by this crisis. Indeed, it had first to face the competition of cheaper British products after the free-trade treaty of 1860. Second, the growing unification of the national French market enhanced by the development of rail-roads increased the competition between large and small factories. This contributed to the progressive de-industrialisation of southern France, unable to compete with the triumphant metallurgic manufacturers of the northern and eastern regions. The concomitant agricultural crisis also reduced the purchasing power of rural inhabitants and therefore the outlets for industrial production. All of this favoured the migration and concentration of industrial workers in towns, which participated in the creation of the French industrial working class [Noiriel, 2002].

[8]This idea, along with the level of industrial performance of the French economy, have been greatly debated. They have been deemed low and stagnating compared to Great-Britain in the 1940s and 1950s, before a revisionist literature insisted on the relatively good economic performance of France during the 19th century and on the distinctive path of growth this country followed [Crouzet, 1966], [O'Brien and Keyder, 1978]. This point of view has subsequently been qualified by authors amending the figures on French productivity growth and insisting anew on the difficulties known by the agricultural and industrial sectors compared to the British ones [Crafts, 1977], [Crafts, 1984]. See [Lévy-Leboyer, 1978] for an analysis of French industrial investment and [Lévy-Leboyer and Bourguignon, 1985] for a macro-economic analysis of French economy along the century. See [Crouzet, 2003] for a historiography of French economic growth during the 19th century, from the "retardation-stagnation" thesis to the "moderate revisionism". To have an economic analysis and description of the industrialisation period in France and other European countries over the century, see [Braudel and Labrousse, 1976], [Verley, 1999] and [Verley, 1997]. For an analysis of the French case under the *Ancien Régime*, see for example [Sée, 1925] or [Woronoff, 1998].

[9]The same was true when taking into account the percentage of the industrial labour-force in each sector. 50% was working in the textile sector at that time, 13% in the building one and 14% in the metallurgy [Noiriel, 2002].

Agriculture still remained the sector gathering the highest share of the labour-force in nineteenth-century France. The 1851 census indicates for example that 53.2% of the total population was belonging to a farming family [Demonet, 1990]. In 1881, 47.5% of the labour-force was concentrated in the agriculture, against 26.7% in the industry ad 24.9% in services. The farms were most of the times small in France at that time. Their average surface area was of 12 hectares in the mid-19th century, but in half of the departments, half of the farms were less than 5 hectares.

Agricultural production increased by 75% in France between 1815 and 1852. The highest growth rates were concentrated under the July Monarchy and were mainly due to the dynamism of livestock farming. The production increased by 80% between 1852 and 1882 before being struck by a severe downturn as for the industry. This phenomenon characterised most of all root crops as sugar beets and potatoes whose cultivated surface area increased respectively by 116% and 61%. This was partly due to a growing individual consumption. Over the period, for example, the average annual consumption of wheat per capita increased by 34%, that of potato by 40% at least, the consumption of sugar by 118% and of meat by 40%. Livestock farming and wine production also peaked in the mid-1870s. Vineyards represented for example 2.5 millions of hectares in 1874. Cereal production was on the contrary stagnating at that time. [Duby and Wallon, 1976].

The evolution was however far from being homogeneous as some regions were already characterised from the 1830s onwards by the rural exodus of their population. This was especially the case for the Massif Central, Lorraine, Alsace, the alpine department and the wooded countryside of Normandie, Maine and Jura. The growth of agricultural production characterised most of all the regions located south of the line going from St-Malo to Geneva. Moreover, the trade balance remained in deficit for many agricultural products. Productivity growth stagnated and a large part of the increase in production appears to have been due to rising prices.

The end of the century downturn is due to several factors. First, a number of specific crises, as the phylloxera in wine and a series of diseases in silk farming. Second, the globalisation of trade and increased competition affected negatively agricultural prices. Third, rural exodus accentuated strongly in the second part of the century, especially in peripheral areas. 55 departments knew a negative evolution of their population between 1881 and 1911, 62 of them between 1901 and 1911. Rural population went from 74.5% to 64.1% and 55.8% of the total population in 1851, 1866 and 1911 [Beltran and Griset, 1994][10]. In this context, agricultural production declined for all products, except for potato and fodder crops. The political reaction to this crisis was a return to more protectionism, notably embodied by the Meline Law in 1892 which increased customs duties on agricultural products.

[10]On this point, see also [Molinier, 1977].

3 Data

3.1 Data on Education

In 1833, when the Guizot Law was passed, a survey at the national level was conducted in order to evaluate the state of primary schooling in France, under the supervision of the French Minister of Education, François Guizot[11]. 490 inspectors were sent throughout France in autumn 1833. All primary schools, both public and private, were to be examined. However, primary schools to which only girls were attending were excluded from the scope of the survey as the Guizot law didn't apply to them. All departments were inspected, except Corsica.
Data coming from the Guizot Survey of 1833 was published for all French districts in a *Report to the King* [Guizot, 1834]. These districts (*arrondissements départementaux* or *sous-préfectures*) correspond to an administrative subdivision of departments (counties). Two to six of them existed in each department. Only some of the questions asked in the initial survey, those deemed of major interest, were aggregated in this report. From the initial individual (at the level of each primary school) forms, the data were collected for 22 departments and 8 129 municipalities[12]. This study will however be made on 21 departments. Indeed, the Bas-Rhin department was not belonging to France any-more after the 1870 Franco-Prussian War. Data on its economic resources are therefore not available at the end of the century. At least one primary school was present in 4 836 of the municipalities (59.5%). This project has been initiated by the *Service d'Histoire de l'Education* of the I.N.R.P, which collected data for the academies of Nantes, Bourges and Nîmes. Other departments were then added to this initial database. In Figure 1, one can see that these departments (in blue) belong to areas with very different levels of enrolment. The Britanny region and the centre part of France with very low levels of enrolment are well represented in the sample. So are the highly educated north-east and the southern part of the country where education was more unevenly distributed, with five departments for each area. To sum up, around 20% of the departments above the St Malo-Geneva line are represented in the sample, against 25% of those below the line[13]. This should ensure a high variation in terms of education and a good representativeness of the data used. Their collection was indeed conducted with the aim of catching all the determinants that underpinned primary schools spreading. This, added to the focus at the municipal level, should helps avoiding some of the criticisms that were pronounced against the reliance of aggregated historical data on primary schools[14]. Other data on education are coming from the *Statistique générale de la France*.

The departments selected are quite representative of France for what regards primary education

[11] A lot of information on this survey is available here : `http://www.inrp.fr/she/guizot/`.

[12] These departments are: Ardèche, Ardennes, Cher, Corrèze, Côtes-du-Nord (Côtes D'Armor), Finistère, Gard, Gers, Indre, Indre-et-Loire, Loire-Inférieure (Loire Atlantique), Loiret, Lozère, Marne, Morbihan, Nièvre, Oise, Bas-Rhin, Saone-et-Loire, Seine-et-Marne, Deux-Sèvres and Vaucluse. At that time, there were 86 departments. Current denominations of departments are specified in brackets when a change occurred.

[13] Excluding the three departments located on this very line.

[14] See for example on this point the criticisms made in [Luc, 1986] and [Luc and Gavoille, 1987]. See [Grew and Harrigan, 1986] for a reply and [Furet and Sachs, 1974] for a use of these data.

and economic characteristics in the first part of the nineteenth century. Taking average values at the level of districts in order to compare this "municipal level sample" to the entire country thanks to the *Report to the King*[15] shows that the number of (public) primary schools doesn't differ significantly between the sample and the entire country. However, enrolment rates and the percentage of municipalities with schools (60.8% against 71.5% for France) are lower in the sample, which means that the departments at stake were less well-endowed in primary schools than at the national level.

Taking data on the height of 20-years old military conscripts to proxy economic resources[16] shows that the departments in the sample were close to the average national level. When considering industrial factors, the sample differs significantly only in the percentage of municipalities with factories (21.6% against 17.2% for France). The number of workers, their average wages, the amount of industrial production or the presence of large factories (more than 20 workers, the top one-third in terms of size) didn't differ significantly between France and the municipality sample. Finally, using the Agricultural survey of 1852 shows no strong difference France and the municipality sample. Either in terms of agricultural area, production organisation or wages, the sample is quite comparable to the national averages.

3.2 Data on Economic Resources

In this article, the economic variable of interest is the amount of taxes per capita collected by municipalities. These data are coming from publications by the Ministry of the Interior entitled *La Situation Financière des Communes de France et de l'Algérie*[17], issued each year from 1878 to 1929. I digitalised the 1881 and 1911 years in order to have a measure of the economic resources of municipalities at the end of the growth phase in nineteenth-century France and just before World War I[18]. I selected two years for several reasons. First, it enables me to check if the results obtained are not linked to a particular year. Second, I am able to study the persistence of the effect of education on resources. Lastly, knowing the timing when education potentially influenced development is useful in specifying the transmission channels between the two phenomena. Data from the industrial survey of 1839-1847 are the other economic data used in order to control for industrial production in the estimations[19].

The nineteenth century was a time of index-based taxation for the state and the municipalities.

[15] See in Table A1 the Appendix.

[16] Data on the height, collected at the level of districts for the 1818-1830 time period on 489 160 twenty years old conscripts (that is to say on men born between 1798 and 1810) is presented and analysed in [Aron et al., 1972]. In 1804, Napoléon instituted a random draw to select the conscripts. Therefore, there is no selection bias with these data as each young men had the same probability to serve. The average height was clearly mirroring the economic development of France. This is in line with other studies exhibiting strong correlations between height, living and health conditions, work at young ages, nutritional intake, ... during the 17th and 18th centuries [Komlos et al., 2003], the 19th century [Villermé, 1829], at the end of this former and during the following [Chamla, 1964], [Meerten, 1990], [Brinkman et al., 1988]. See [Steckel, 1995] for a review of the literature on this point.

[17] The financial situation of municipalities of France and Algeria.

[18] I selected these years and not 1878 and 1913 for example because they were also census years. I thought that the quality of the data could be improved by this.

[19] More information on this survey can be found in [Chanut et al., 2000].

This system, implemented during the revolutionary period, remained remarkably stable all along the century and no major modifications were implemented to it before the creation of the income tax in 1914. The *Assemblée Constituante* implemented in 1791 a land tax, a personal property tax on incomes coming from other sources than land and commercial activities and a *patente* tax on these commercial resources. An additional tax on the number of doors and windows of habitations was later implemented in 1798. These four taxes, known as the *Quatre vieilles*, constituted the direct "contributions", as they were called, entering the state and municipalities budgets.

The land tax was based on net incomes coming from the use of lands[20], which were evaluated on the 15 preceding years[21]. The personal property tax was composed of two distinct elements: the taxpayer had first to pay an amount equal to the average value of three workdays. This amount was fixed in each department. The second part of the tax was based on the rental value of personal residential buildings. The basis of the *patente* tax was incomes coming from trade and industry. However, it is only by means of rental value that these resources were taxed. The *patente* amounted to a percentage between 10 and 15% of the rental value of buildings. In industry, additional component depended directly on the number of workers and engines used in the production process [Chanut et al., 2000]. Bakers had the privilege to pay half the tariff while beverage merchants had to pay the double. Since any trading activity was taxed by the *patente*, it reflects perfectly the commercial and industrial activity of the municipalities. The tax on doors and windows was positively related to their number and size. After 1832, the amount was higher in more populous municipalities. Also, the *patente* was the only flat tax of the four, the other other three were "impôt de répartition", which means that the amount expected to be drawn from them was decided first by the state, and then divided between municipalities according to their estimated economic resources [Neurrisse, 1996].

Municipalities could also decide to increase what they were perceiving from these taxes by collecting "additional cents" on them. This was done by increasing the rate of the taxes. For example, collecting 3 additional cents was equivalent to ask taxpayers to pay 3 cents more for each franc of tax, which amounted to an increase of 3% in the rate. This was usually implemented to built or maintain byroads or in case of deficit. Additional taxes as the one on dogs implemented in 1855, on private pool tables (1871) or velocipede (1893) were also entering the municipalities' budget but they were marginal compared to the four direct taxes described.

Municipalities could also make use of resources coming from the *octrois*, which corresponded to indirect taxes on products imported and sold within the delimitations of the municipality[22]. However, only the biggest municipalities were concerned by these indirect taxes. 1 538 of them were raising *octrois* in 1881, 1 523 in 1911[23].

[20]It is only in 1881 that a distinction between built-up and non-built-up property was introduced. Built-up property was from then on taxed according to its rental value.

[21]The two best and worst years were excluded from the computation. See for example [Kang, 1993] on this tax.

[22]These *octrois* had been suppressed in 1791 and progressively reintroduced from 1798 onwards. Taxes on beverages were for example re-established in 1804, in 1806 for those on salt.

[23]They could constitute a crucial source of income for big municipalities. For example, in 1913, half of the resources of Paris were coming from these indirect taxes. The budget of the state was also critically depending

The crucial point here is to know exactly what dimension of economic resources these tax data refer to. Is it to the resources of people or of places ? Since the taxes are mainly direct for the vast majority of municipalities, their amount should greatly reflect the resources or people. In this sense, the effect of education on taxes can be partly seen as being close to returns to schooling. However, many taxpayers were owning properties in a different municipality from the one they were living in. The same thing could also be said about the *patente*. To a lesser extent, manufacturers could live in a different municipality from where their industry was located. Moreover, there is no way to control for the migration of people over the 47 years separating the measure of education from the first on taxes. Therefore, this paper is closer to urban economic studies evaluating the impact of education on the growth of cities. The main difference is that these studies often focus on big towns, while around 90% of the municipalities in my sample are less than 2 000 inhabitants. Moreover, they often choose population growth as the outcome of interest while I focus here on the economic resources of municipalities. I therefore rather measure the impact of education on the economic growth of local places.

3.3 Demographical Data on Municipalities

Data on the population of municipalities from the censuses is taken from [Motte et al., 2003]. Population dispersion is taken from the Postal Survey of 1847 along with the surface area of municipalities which have disappeared or merged since 1833[24]. Since this survey is posterior to the Guizot one, I have to assume that population remained stable over the fourteen years separating them, which seems to be a quite reasonable assumption. The *Institut national de l'information géographique et forestière*, a public organism in charge of the diffusion of geographic information in France, provides surface data for the other municipalities. The altitude of municipalities is also taken from this organism.

3.4 Descriptive Statistics

Descriptive statistics are displayed in Table 1. Primary schools were located in 59% of the municipalities in the data. Around 47% of the municipalities were subsidising primary schooling. Pupils spent on average 5 years at school and the number of pupils per 100 inhabitants was around 10 in municipalities with primary schools. The average taxes per capita nearly doubled between 1881 and 1911, from 7.5 to 13.3 francs[25]. This increase may partly reflect economic growth. It is also due to the fact that, after 1905 and the passing of the law separating churches and state, resources saved from the suppression of worship budget were split between municipalities according to their contribution to land tax on non-built property.
The average population of the municipalities was around 990 inhabitants in 1833, but 50% of

on indirect taxes. Registration duties, customs duties and taxes on sales of beverages and transports were constituting half of its budget in the 1830s, 53% in 1913. Direct taxes followed the opposite trend, from 30% to 10% of the budget between the same dates.

[24]More information on this survey is available in [Marin and Marraud, 2011].

[25]Figure B1 and Figure B2 in the Appendix display the distribution of enrolment, schooling years and taxes per capita.

them were less than 631 inhabitants and 90% less than 2 000. Population dispersion could be high within municipalities as the average scattering was around 47%, with a median value close to 50%. Information on printing presses refer to the instruments used in the instrumental variable estimations. More precision are provided on this point in Section 5.

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Primary School - 1833	0.59		0	1	8129
Public school - 1833	0.47		0	1	8129
Pupils per 100 inhabitants - 1833	9.5	6.8	0.3	61.6	4658
Schooling years - 1833	5.3	1.9	1	9	4629
Municipal income, francs per capita - 1881	7.5	10.3	0.4	469.4	7295
Municipal income, francs per capita - 1911	13.3	10.1	0.3	305.9	7302
Population - 1833	989.8	1811.9	30	75895	8064
Percentage of population scattered	46.8	35.6	0	100	6941
Population growth - 1793-1836	30.1	58.2	-88.4	1500	7931
Surface area - hectares	1725.5	1439.1	8	18359	7844
Average altitude - meters	207.7	194.6	1	1399	7844
Industrial production - francs per year	71.5	1167.9	0	59138	8129
Postal taxes - cents of francs	114.5	428.6	0	27894	8129
Distance to post office - kms	7.1	4.6	0	116	7302
Distance to prefecture - kms	36.2	16.9	0	128.3	7844
Distance to printing press - kms	61.1	38.4	0	256.3	7273
Printing presses within 75kms	1.3	1.1	0	5	7273
Printing presses within 100kms	2.2	1.5	0	9	7273
Printing presses within 150kms	5.2	2.8	0	13	7273

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*. [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: All variables are defined at the municipal level. The postal taxes correspond to the amount of taxes collected on postal activity within the two-week period when the postal survey was conducted.

4 A Regression Discontinuity Design Based on the Guizot Law

Descriptively speaking, the level of taxes per capita was positively correlated with enrolment rates and schooling years. In Figure 2, I display this relation for years 1881 and 1911[26]. These

[26]When more than one school was present in a municipality, I computed schooling years as the mean between the average value within each school.

two measures can be taken as good proxies for human capital accumulation at the beginning of the nineteenth century in France. Indeed, since learning and teaching were thought in a more linear way than today, subjects like reading, writing, the arithmetic, ... were learnt one after another within primary schools [Furet and Ozouf, 1977b]. Therefore, higher average schooling years were very likely to be synonymous with more subjects learnt and with a higher mastering of these subjects [Montalbo, 2019]. This proxy for intensive human capital accumulation is complemented by enrolment rates working as a proxy for the extensive accumulation.

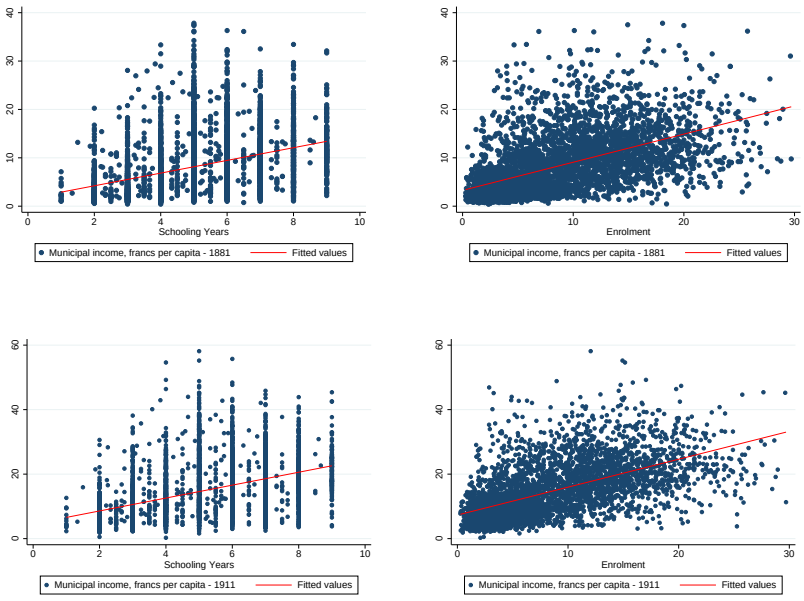


Figure 2: Scatterplots of income, enrolment and schooling years

Source: Guizot survey and *La Situation Financière des Communes*.

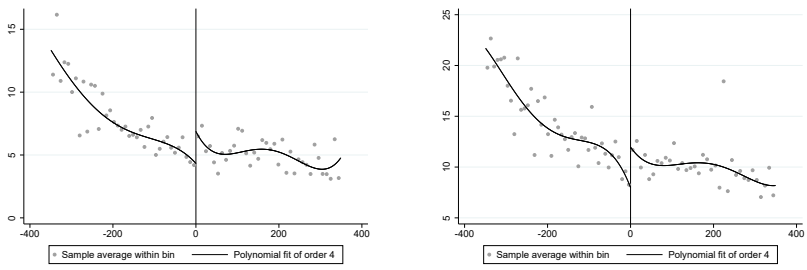
Since the measure of economic resources is posterior to the one of schooling, there is no reverse causality issue here. However, one might fear that wealthy municipalities would invest more in education at the beginning of the century, these very municipalities being also characterised by high amount of resources later on. In this case, the effect of schooling would be badly estimated with simple OLS. In this section, I take advantage of the fact that the Guizot Law made mandatory for municipalities more than 500 inhabitants to open and finance a primary school after 1833. Thanks to the Guizot survey, I can know which municipalities had no school at that time. I therefore selected them and apply a regression discontinuity around the threshold of 500 inhabitants[27].

This strategy bears some drawbacks as I cannot know if municipalities below the threshold opened or not a school just after 1833. However, as they were very small and had not done so before, there is only a very little probability that a high number of municipalities just below

[27]See [Lee and Lemieux, 2010] for a literature review of regression discontinuity designs in economics.

the threshold would do so just after the law while they had no legal obligation to open a school. Therefore, these municipalities were certainly characterised by a long-lasting absence of primary school during the nineteenth-century. If some of them did open a school anyway, the following estimations would return a lower bound for the impact of primary schooling on economic development. Finally, I cannot measure the effect of enrolment rates or schooling years using this strategy. I will therefore only be able to evaluate the impact of a primary school's presence. However, monographic studies report that the positive supply shock on education caused by the Guizot Law contributed to increase significantly enrolment rates [Thabault, 1993], [Blanc and Wacziarg, 2018]. Therefore, the presence of a primary school after the law was passed was very likely to be associated with a higher human capital accumulation in the municipality at stake.

In Figure 3, I plot the data-driven regression discontinuity in municipal resources according to the difference between municipal population and the 500-inhabitant threshold in 1881 and 1911. The resources per capita were decreasing in population between 100 and 500 inhabitants. Very small municipalities had therefore on average higher economic resources per capita than municipalities around the 500 inhabitant threshold. There is a jump in resources around this threshold, which become much more stagnant afterwards. This indicates a discontinuity in resources related to the presence of a primary school[28].



1881 1911

Figure 3: Data-driven regression discontinuity in municipal resources per capita

Source: Guizot survey and *La Situation Financière des Communes*.
Notes: On the x-axis, the distance in terms of population to the 500-inhabitant threshold is displayed. The polynomial fit used is of order four. The number of bins has been selected through the mimicking variance evenly-spaced method using spacings estimators. For the 1881 year, 38 bins are selected left to the threshold, with an average length of 9 inhabitants. 36 bins are selected right to the threshold, with an average length of 9.7 inhabitants. The respective figures for 1911 are of 43 and 35 bins, with average lengths of 8 and 10 inhabitants.

As recommended in [Imbens and Lemieux, 2008] or [Lee and Lemieux, 2010], one should check several conditions in order to account for the reliability of the regression discontinuity approach. The first one is the continuity of the running variable density (here population) around the threshold. If this variable can be completely manipulated by the units in order to obtain or

[28] See Figure B3 for discontinuities computed using different polynomial orders.

avoid a given treatment, then the regression discontinuity will be biased. If the manipulation is only partial, the estimations will remain valid [McCrary, 2008]. In this case, a complete manipulation would arise if, knowing the 500 inhabitant threshold of the Guizot Law and anticipating its passing, municipalities around this threshold tried to artificially lower their population level in order to avoid having to open and fund a primary school. This seems to be unlikely. This idea is reinforced by a graphical analysis exhibiting no discontinuity of population density around the threshold[29]. A manipulation test, implemented following [Cattaneo et al., 2018], returns a p-value of 0.6591, confirming the fact that municipalities didn't manipulate the forcing variable around the threshold.

Therefore, I turn to the estimations following the non-parametric model :

$$Y = \alpha + \tau D + \beta_1(X - c) + \beta_2 D(X - c) + \varepsilon \tag{1}$$

where Y if my variable of interest, namely taxes per capita in 1881 and 1911, and X the population level. Let c be the treatment cut-off and D a binary variable equal to one if $X \geq c$. Let h being the bandwidth of data used, then it follows that $c - h \leq X \leq c + h$. In this model, different slopes and intercepts fit data on either side of the cut-off. In Table 2, I report the estimation outcomes using a flexible linear and quadratic specification and using different population bandwidth, from 50 to 150 inhabitants. I report also a bandwidth of 105.9 for the year 1881 and 90.3 for 1911, selected as optimal bandwidths using the *rdbwselect* command in *Stata* [Calonico et al., 2017].

[29] See Figure B4 in the Appendix.

Table 2: Non-parametric regression discontinuity estimates - Municipal resources per capita, 1881 and 1911

	Flexible linear					Flexible quadratic				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RD Estimate - 1881	3.002***	2.295***	1.302*	1.159*	1.320**	3.180**	3.237***	2.989***	2.470**	1.739*
	(3.034)	(2.745)	(1.751)	(1.745)	(2.243)	(2.126)	(2.641)	(2.693)	(2.536)	(1.932)
Observations	347	500	694	804	957	347	500	694	804	957
Population bandwidth	50	75	105.9	125	150	50	75	105.9	125	150
RD Estimate - 1911	4.039***	2.927***	2.495**	1.744**	1.549**	4.711**	4.943***	4.179***	3.804***	3.044**
	(3.190)	(2.740)	(2.473)	(2.020)	(2.013)	(2.448)	(3.187)	(2.857)	(2.959)	(2.528)
Observations	350	503	599	806	961	350	503	599	806	961
Population bandwidth	50	75	90.3	125	150	50	75	90.3	125	150
Covariates	No	No	No	No	No	No	No	No	No	No

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: I report the estimation outcomes using a flexible linear and quadratic specification and using different population bandwidth, from 50 to 150 inhabitants. I report also a bandwidth of 105.9 for the year 1881 and 90.3 for 1911, selected as optimal bandwidths using the *rdbwselect* command in *Stata* [Calonico et al., 2017].

Results show a positive impact of education on the economic development of municipalities, with a magnitude between 1.5 and 3 francs per capita depending on the bandwidth selected. As expected, the magnitude is higher closer to the threshold. Primary education contributed therefore to increase the economic resources of municipalities during the nineteenth century and until World War I.

The effect is therefore robust to the choice of different population bandwidth. In Table 3, I run the same kind of model using a kernel estimation with the *rdrobust* command [Calonico et al., 2017] and the optimal bandwidth selection associated to it[30]. The difference between columns (1), (5) and (2), (6) is that I include covariates in the last two[31]. In columns (3) and (7), I add covariates which are also incorporated in the computation of the optimal bandwidth, which is not the case in columns (2) and (6). Finally, I cluster standard errors at the district level in columns (4) and (8). All the specifications return positive and significant outcomes, with a magnitude of around 2 francs per capita. This is close to one-third of a standard deviation in economic resources[32]. The impact of primary schools' presence is therefore also robust to the inclusion of covariates, the choice of a kernel estimation and the use of clustered standard

[30] See for example [Imbens and Kalyanaraman, 2012] on the optimal bandwidth selection.

[31] These covariates are the same ones that I will use in the instrumental variable estimations, namely : population dispersion (taken as the share of the total population that didn't match the contiguity criterion. See [Roncayolo, 1987] on this point), surface area, altitude, population growth 1793-1836, postal taxes, the distance to the post office and to the prefecture, latitude, and a dummy variable indicating if the municipality at stake is in a department with a printing press.

[32] See Figure B5 in the Appendix for a graphical representation of the effect estimated.

errors[33].

These results remain consistent with the estimation of several robustness checks. The use of a coverage error rate (CER)-optimal bandwidth instead of a mean square error (MSE)-optimal one doesn't modify greatly the outcomes. The is also true for the manual selection of various bandwidths (the same as in Table 2) under the same kernel estimation[34]. Finally, two important things remain to check when working with regression discontinuities. First one needs to investigate the continuity of covariates around the threshold. Second, it is necessary to run falsification tests in order to show that there is no other discontinuities having an impact on the variable of interest. Indeed, a discontinuity in covariates would cast doubt on the comparability between municipalities above and below the threshold. Also, the existence of unexplained discontinuities around different population cut-offs would weaken the reliability of the estimation. Outcomes of Table A4 and Table A5 in the Appendix reject these two issues. This reinforces the strength of the regression discontinuity design used and the reliability of the impact of education on the economic development of municipalities[35].

[33] As specified in [Lee and Lemieux, 2010], the inclusion of covariates should not lead to a different outcomes in a regression discontinuity design. Indeed, if the setting is good and therefore close to a randomised experiment, then the assignment to treatment is, by construction, independent of the baseline covariates. However, the adding of covariates reduces the sampling variability in the estimator. A substantive precision was gained as confidence intervals shrank by around 10% with the inclusion of covariates from column (1) to (3). This is in line with the recent work of [Calonico et al., 2019].

[34] See Table A2 and Table A3 in the Appendix.

[35] For the falsification tests, I don't estimate them on population cut-offs superior to 2 000 inhabitants since this would highly restrict the number of observations. There is for example only 49 municipalities in the data between 1 900 and 2 100 inhabitants without schools.

Table 3: Non-parametric regression discontinuity estimates - Municipal resources per capita

	1881				1911			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RD Estimate	2.009***	1.856***	2.417***	2.254***	3.166***	2.211***	1.815**	1.698*
	(2.63)	(3.14)	(3.45)	(3.00)	(3.00)	(2.62)	(2.41)	(1.86)
Controls	400	333	222	261	339	285	366	388
Treated Units	294	245	182	208	260	212	264	284
Covariates	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Left Clusters				67				72
Right Clusters				62				66
Kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Order Loc. Poly.	1	1	1	1	1	1	1	1
Order Bias	2	2	2	2	2	2	2	2
BW Loc. Poly.	105.9	105.9	73.21	84.40	90.31	90.31	116.7	126.1
BW Bias	188.5	188.5	142.4	148.1	170.3	170.3	218.5	219.4

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.
Notes: In columns (3) and (7), I add covariates which are incorporated in the computation of the optimal bandwidth. This is not the case in columns (2) and (6) where the covariates are added without entering in the computation of the optimal bandwidth. I cluster standard errors at the district level in columns (4) and (8).

5 Printing Press as an Instrumental Variable

5.1 Printing Press and Primary Education

The use of an instrumental variable (IV) technique will enable me to evaluate the effect of schooling years and enrolment rates on the economic development of municipalities. I will also be able to assess this effect on all municipalities and not only small ones concentrated around the 500-inhabitant threshold. The idea is to use the distance of municipalities to the nearest printing press established before 1500 along with the number of printing presses within a given radius as instruments for primary schooling.

Indeed, education seems to have developed close to the location of the first printing presses in France. This is especially true for the north-eastern part of the country located near Mainz, the town where the first printing press was established by Gutenberg around 1450. The distance to this city has already been used as an instrument for primary education [Diebolt et al., 2017b]. The main idea behind the use of these instruments is that printing presses favoured the dissemination of written culture, the presence of teachers, scholars and administrative activities which required higher educational achievements. During the second half of the 15th century, printing presses were mainly established in ecclesiastical and student cities. Indeed, most of the printing industry's outlets were located there. A high concentration of legal professionals and rich merchants was also attracting printers. Paris, Lyon and Venice rapidly became the

most active printing places in Europe. 45% of the books printed before 1500, the incunabula, were related to religion, 30% to medieval literature, more than 10% related to legal matters and around 10% to scientific subjects [Febvre and Martin, 1999]. The printing press didn't really enhance the diffusion of new scientific ideas, but it helped spreading the access to classical authors as Aesop, Cato and Seneca, or later to humanist writers like Erasmus.

The printing press has long been considered as a key determinant in the diffusion of literacy during the Renaissance period in Europe [Grendler, 1990]. This effect, which can only have been very gradual [Eisenstein, 1980], still lacks evidence. However, it has been recently identified in the case of Sub-Saharan countries [Cagé and Rueda, 2016]. The important questions here are twofold. First, what are the reasons why the printing press would have influenced the diffusion of education in small municipalities around the towns where it was established ? And second, if this effect is true, was it really strong enough so that printing presses could be used to instrument primary education in 1833 ?

It is true that the diffusion of books in the hands of religious people, lawyers or students is likely to have been concentrated within big towns. However, the higher dissemination of written culture may have reached even the small municipalities around these towns through several channels. Firstly, the increase in literacy and education in big towns is very likely to have positively influenced the concentration of teachers. These teachers may then have looked for smaller municipalities where the competition between them was low to settle in. This effect was certainly very gradual.

A more direct effect was due to the activity of peddlers who were travelling from municipality to municipality to sell books. Knighthood novels were in particular extremely popular during the 15th and 16th centuries and likely to be sold by peddlers [36]. The increasing number of books written in vernacular language and not Latin, already 22% in the 15th century, also favoured this diffusion [Febvre and Martin, 1999][37]. Peddlers' activity is very likely to have been concentrated around towns with printing presses because of the higher transaction costs associated with high travelling distances. Even if only a few people could afford to buy books at that time and even in the 19th century, their presence in a given municipality may have positively influenced the culture of the whole village [Eisenstein, 1968]. Moreover, before the 19th-century mass movements of education, literacy was often taught to children in small municipalities by parents, neighbours, or by the only literate person living in the village [Laqueur, 1976]. Parish priests also often assumed this task in rural France. Therefore, if the printing press contributed to increase even by a small amount the share of people able to deliver this kind of teaching, this has certainly influenced people's taste for education and the diffusion of literacy.

Another very important transmission channels is constituted by the influence of printed sheets describing local celebrations, the conduct of a battle, ... and which were stuck on a wall in plain sight within municipalities. The printing press contributed to increase their number

[36] Books like the *Quatre fils Aymon* or *Fierabras* knew a large diffusion at that time.

[37] The use of vernacular language has been intensively promoted under the reigns of Louis XII (1498-1515) and François Ier (1515-1547) in France. This phenomenon therefore followed very closely the introduction of the printing press.

and their diffusion [Febvre and Martin, 1999]. Once again, this phenomenon is very likely to have taken place, or to have been more intense, in the municipalities close to the printing press. The dissemination and multiplication of these sheets increased the contacts between the inhabitants and written culture. This certainly increased the incentives to master literacy in the municipalities at stake. The diffusion of Protestantism has also been linked to the printing press. However, in the case of France, it is hard to assert that printing presses particularly helped its diffusion. This effect seems to have been stronger in Germany.

In order to evaluate the association between the printing press and primary schooling, I use the same data sources as in [Dittmar, 2011], the *Incunabula Short Title Catalogue* [ISTC, 1998] maintained by the British Library and *L'Apparition du livre* by Febvre and Martin [Febvre and Martin, 1999]. I select the 39 French cities where a printing press was established in 1500 and some Belgian, Swiss, German, Dutch, Italian and Spanish cities that could fall within the radii selected around municipalities. The 80 cities present in the database are depicted in Figure 4.

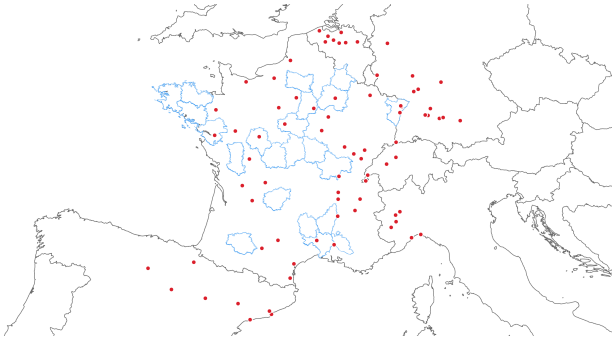


Figure 4: Location of printing presses in 1500

Source: [ISTC, 1998] and [Febvre and Martin, 1999].
Note: Departments in blue are the ones for which education data are available at the level of municipalities.

Descriptively, there is a positive correlation between the distance to the nearest printing press, the number of printing presses within 100 kms, schooling years and enrolment rates. I depict this relation in Figure 5, dividing the scatterplots on enrolment by population bounds to ensure a higher homogeneity of the age structure between municipalities. On average, pupils were more numerous and stayed at school during a higher number of years when located closer to printing presses. I keep municipalities without schools in the analysis. The log of enrolment is therefore computed as $ln(1 + enrolment)$ in order to take into account the zero-value rate. I take a 100kms radius since a lower one would reduce too highly the number of printing presses around municipalities. Indeed, with a 75kms radius, this number would only vary between zero and five. A higher threshold would lower the precision of the association with education. Indeed, printing presses located far away from the municipalities at stake are less likely to have influenced significantly primary schooling.

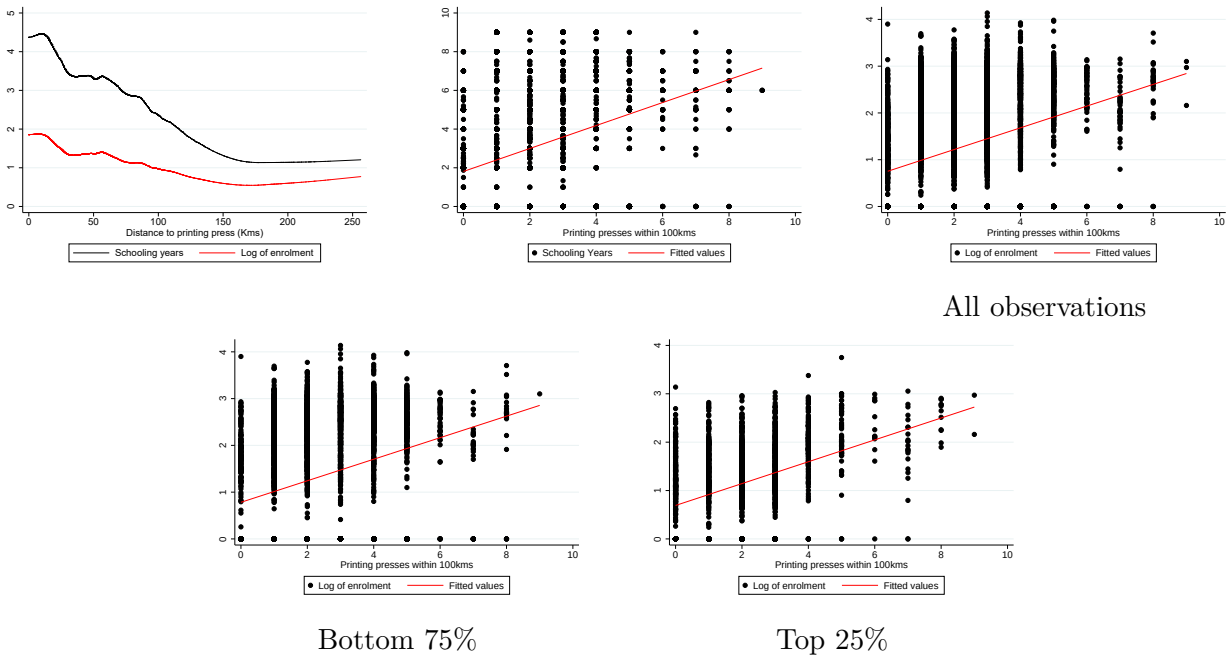


Figure 5: Distance to the printing press, printing presses within 100kms, schooling years and enrolment. Locally weighted scatterplot smoothing and scatterplots.

Source: Guizot survey, [ISTC, 1998] and [Febvre and Martin, 1999].
Note: A bandwidth of 0.25 is applied for the locally weighted scatterplot smoothing. Scatterplots on enrolment rates are divided by population bounds.

This is confirmed by the estimation of the following first stage :

$$Educ_m = \alpha + \beta_1 Instr_m + \beta_2 Demo_m + \beta_3 Eco_m + \epsilon_{m,arr} \tag{2}$$

where $Educ_m$ represents schooling years or enrolment rates measured within the municipality m. $Instr$ is the instrument used, namely the distance to the nearest printing press or the number of printing presses within 100 kms. $Demo$ stands for the demographic and geographic characteristics of municipalities and Eco for variables related to their potential economic resources. Standard errors indexed by arr are clustered at the district level. This is done in order to account for spatial correlation either when using OLS [Moulton, 1986], [Moulton, 1990] or using IV estimations [Shore-Sheppard, 1996], [Hoxby and Paserman, 1998]. Indeed, the education residual is likely to be correlated at the department and district levels.
For what regards demographic and geographic variables, I control by the average altitude of municipalities, their surface area, their latitude, their total population in 1833 and by the share of their population that is considered to have been scattered. Mountainous land is expected to have been a potential barrier to economic development, as well as the population dispersion. Indeed, a high dispersion was implying longer travel times and a less accessible workforce. Population should on the contrary be positively correlated with economic development. Latitude is expected to control for potential temperature and soil quality differences between municipalities. The economic controls are population growth between 1793 and 1836, the distance to post office, the amount of postal taxes collected in municipalities, the level of industrial production

and the distance to the prefecture. Postal activity was clearly reflecting economic dynamism in the mid-19th century since most of the letters were sent by businessmen [Chartier et al., 1991], [Richez, 2002][38]. I also add a department dummy variable indicating if municipalities were located in a department with a printing press in 1500.

Distance to the printing press and the number of such presses within 100 kms appear to have been significantly linked to the presence of primary schools, schooling years and enrolment rates. The outcomes of Table 4 indicate that increasing this distance by one kilometre was reducing the probability to find a primary school in the municipality at stake by 0.3%. This was also implying a reduction of 0.02 schooling years, of 0.8% in enrolment rate for municipality less than 1 109 inhabitants (bottom 75%) and of 0.4% in municipalities above this threshold. One more printing press within 100kms was associated with the respective increases of 8.5% for the primary school probability, 0.6 schooling years and around 20% in enrolment.
In order to reinforce the idea of a link between the printing press and primary schooling, I also made use of the first literacy measure available for France in 1686-1690. Literacy is computed as the percentage of people being able to sign their marriage contract and is available at the level of departments. Figure B6 in the Appendix depicts the spatial distribution of literacy rates. It is very close to the one in 1833 represented in Figure 1. The spatial inequalities in education achievements remained indeed very stable in France between the 17th century and the mid-19th century [Lebrun et al., 2003]. Table A6 in the Appendix shows that the number of printing presses in 1500 was positively related to both the literacy level of men and women in 1686-1690[39], with a magnitude of around 1% for women and 1.7% for men. Therefore, the printing press was early associated with primary schooling and, due to the absence of other factors enhancing an education convergence between departments, its effect remained significant even at the beginning of the 19th century.

[38]These variables are also expected to have influenced primary schooling. Population dispersion is likely to have impacted negatively primary schooling by increasing the distance from habitations to schools and therefore decreasing the number of pupils [Furet and Ozouf, 1977b]. Mountainous land is expected to have had the same effect. Population should, on the contrary, have increased the potential number of pupils and the resources municipalities could dedicate to education. Economic controls are likely to have been positively related to primary schooling.

[39]I compute this number within 150kms around the administrative centre of each department. I am forced to increase the distance in these estimations since, for many departments, only a very small amount of printing presses was located within lower radii.

Table 4: OLS estimations - Primary schooling and printing presses

	Primary school		Schooling years		Log of enrolment			
Population intervals:					Bottom 75%		Top 25%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance to printing press (kms)	-0.003***	–	-0.021***	–	-0.008***	–	-0.004**	–
	(-3.273)		(-4.408)		(-3.594)		(-2.603)	
Printing presses within 100kms	–	0.085***	–	0.589***	–	0.223***	–	0.193***
		(3.970)		(4.223)		(3.442)		(6.328)
Population dispersion	-0.004***	-0.005***	-0.030***	-0.032***	-0.012***	-0.013***	-0.013***	-0.012***
	(-6.782)	(-7.820)	(-6.650)	(-7.556)	(-6.777)	(-8.027)	(-8.378)	(-9.015)
Population	0.0001***	0.0001***	0.001***	0.0001**	0.001***	0.000***	-0.000	-0.000
	(4.765)	(4.621)	(2.987)	(2.558)	(3.594)	(2.955)	(-1.051)	(-0.976)
Surface area	-0.000	-0.000	-0.002**	-0.001	-0.002***	-0.001*	-0.001***	-0.0005**
	(-1.378)	(-0.356)	(-2.012)	(-0.893)	(-3.005)	(-1.814)	(-3.783)	(-2.601)
Altitude	-0.000	-0.0002*	-0.000	-0.000	-0.000	-0.000	0.000	0.000
	(-1.373)	(-1.840)	(-0.128)	(-0.582)	(-0.598)	(-1.056)	(0.899)	(0.269)
Population growth - 1793-1836	-0.000	-0.000	0.000	-0.000	0.000	-0.000	-0.000	-0.001
	(-0.487)	(-0.962)	(0.152)	(-0.418)	(0.120)	(-0.068)	(-0.653)	(-1.630)
Distance to post office	-0.003	-0.003	-0.016	-0.016	-0.003	-0.002	-0.004	-0.004
	(-1.442)	(-1.422)	(-1.244)	(-1.242)	(-0.441)	(-0.398)	(-0.889)	(-0.886)
Postal taxes	-0.000	-0.000	-0.000	-0.000	0.000	0.000	0.000	0.000
	(-0.983)	(-0.856)	(-1.364)	(-1.220)	(0.534)	(0.691)	(1.126)	(1.182)
Industrial production	0.0001*	0.0001**	0.0005**	0.001**	0.000	0.000	0.000	0.000
	(1.860)	(2.208)	(2.055)	(2.395)	(0.595)	(0.550)	(0.821)	(1.443)
Distance to prefecture	0.000	-0.001	0.002	-0.006	-0.001	-0.004	0.003	0.001
	(0.288)	(-0.595)	(0.257)	(-0.698)	(-0.293)	(-1.156)	(1.466)	(0.504)
Latitude	-0.005	-0.018	0.257**	0.164	0.119***	0.084*	0.029	0.005
	(-0.324)	(-1.111)	(2.374)	(1.474)	(2.883)	(1.937)	(0.888)	(0.161)
Dep. with printing press	-0.171**	-0.198**	-1.150**	-1.249**	-0.518**	-0.557**	-0.076	-0.204
	(-2.169)	(-2.454)	(-2.239)	(-2.377)	(-2.437)	(-2.396)	(-0.457)	(-1.470)
Observations	6081	6081	5939	5939	4769	4769	1227	1227
R^2	0.154	0.176	0.255	0.275	0.272	0.290	0.373	0.416
Clusters	91	91	91	91	89	89	86	86

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003], [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: *Primary school* is a dummy variable taking value one if a school was located in the municipality at stake. Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

5.2 Printing Press and Economic Development

A problem with these instruments could arise if the presence of printing presses or their concentration within a given radius is correlated with the economic development of municipalities before the nineteenth century. If richer municipalities were establishing printing presses and developing primary education at the same time, then these presses would only reflect the higher economic resources of the municipalities at stake. According to [Dittmar, 2011], the presence of a printing press contributed to the population growth of cities between 1500 and 1800, thanks

to its effect on "the acquisition and development of skills that were valuable to merchants and businessmen". Therefore, at first sight, these instruments may seem to be invalid. However, the study of Dittmar focuses only on the cities where the printing press was established. This amounts to 39 towns for France. Moreover, the data from [Bairoch et al., 1988] indicates that these cities were highly populated, around 18 000 inhabitants on average, which clearly makes them particular cases compared to the "average municipality" at that time. Even in 1793, only 5% of all municipalities in France were more than 1 900 inhabitants, only 0.17% more than 18 000 inhabitants.

The crucial assumption that I make at this stage is that, even if the printing press contributed to the growth of cities in France, they didn't influence significantly the economic development of smaller municipalities, even when they were located close to them. This assumption is in compliance with the effects of the printing press on economic growth which were identified to have been very localised within big towns [Dittmar, 2011]. Moreover, printing presses had a positive effect of the population growth of towns. If part of this effect went through an increase in migrations coming from nearby municipalities, this would have thwarted the potential positive effect of the press on these very municipalities. I computed several robustness checks on the IV estimations, excluding municipalities close to the cities with a printing press. This didn't modify the outcomes, which reinforces the idea that the instrument is not associated with a positive income effect of printing presses on growth.

One could still be afraid that municipalities with a printing press would drive the outcomes or break the exclusion restriction. Ten municipalities in my database had a printing press in 1500 [40]. However, they are excluded from the IV estimations. Indeed, I include postal controls to check for municipal economic dynamism. One specificity of the postal survey is that it was implemented mainly on small municipalities. Big towns more than 10 000 inhabitants for example were excluded from the survey[41]. As this was the case for seven towns over the ten with the printing press, I excluded also the other three from the analysis. Adding them to the estimations by letting aside postal controls doesn't modify the outcomes[42].

In Table 5, I provide a first indication that the exclusion restriction is very likely to hold. In columns (1) to (4), I take population data from [Bairoch et al., 1988] in order to evaluate if the presence of a printing press in a given town influenced positively its population and economic growth[43]. I find no significant impact of this presence, either between 1700 and 1750 or between 1700 and 1800. Therefore, the growth of large cities during the 18th century was actually not significantly influenced by the printing press in France. This outcome indicates that small municipalities around cities are not likely to have benefited from economic spillovers caused by the printing press.

[40] These municipalities are: Anduze, Tours, Nantes, Orléans, Châlons-en-Champagne, Haguenau, Strasbourg, Provins, Mâcon and Avignon.

[41] On this point, see for example [Poublan, 1997-1998].

[42] Results available upon request.

[43] On the use of population as a proxy for economic development, see for example [Vries, 1984] and [Acemoglu et al., 2005].

In columns (5) to (8), I evaluate its impact on the population of the municipalities in my database, 40 years before my measure of primary schooling and nearly 90 years before my proxy for economic development. Again, I find no significant link between the printing press and population growth. Municipalities historically close to the printing press were therefore not growing significantly more than the others in the early 19th century. Also, I find no impact of the printing press on the level of industrial production within municipalities or on the amount of postal taxes collected in the mid-19th century[44]. Municipalities close to the first presses were not significantly richer than their counterparts at the beginning of the period under scrutiny in this work. Therefore, there is no strong reason to think that the pre-19th century economic development of municipalities in my database was significantly influenced by the printing press.

Table 5: Printing press instrument - Exclusion restriction using population levels

	Bairoch et al. population data				Municipalities from the Guizot survey			
	Pop. growth 1700-1750		Pop. growth 1700-1800		Population - 1793		Pop. growth 1793-1836	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Printing presses within 100kms	-0.253	–	5.485	–	15.099	–	2.755	–
	(-0.165)		(1.245)		(0.554)		(1.210)	
Distance to printing press (kms)	–	0.088	–	-0.221	–	-0.066	–	0.016
		(1.145)		(-0.936)		(-0.038)		(0.370)
Surface area	0.000	0.000	-0.000	-0.000	4.757***	4.736***	-0.020***	-0.025***
	(0.204)	(0.338)	(-0.116)	(-0.171)	(8.083)	(7.906)	(-2.634)	(-3.480)
Altitude	-0.012	-0.010	-0.023	-0.014	-0.862***	-0.848***	-0.003	-0.000
	(-0.841)	(-0.776)	(-0.584)	(-0.358)	(-4.289)	(-4.095)	(-0.261)	(-0.002)
Latitude	0.531	0.822	-0.810	-0.340	-4.717	-3.105	-1.715	-1.456
	(0.490)	(0.767)	(-0.242)	(-0.103)	(-0.327)	(-0.223)	(-1.277)	(-1.072)
Printing city	1.427	6.785	-8.128	-14.383	–	–	–	–
	(0.232)	(0.892)	(-0.419)	(-0.611)				
Dep. with printing press	–	–	–	–	26.959	50.874	-3.781	1.966
					(0.328)	(0.645)	(-0.836)	(0.459)
Observations	141	141	163	163	7114	7114	7080	7080
R^2	0.010	0.020	0.011	0.006	0.148	0.148	0.008	0.005
Clusters					92	92	92	92

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: [Motte et al., 2003], postal survey, [ISTC, 1998], [Febvre and Martin, 1999] and [Bairoch et al., 1988].

Estimations at the level of departments complement this analysis. In Table 6, I find no significant link between the printing press and several development indicators, the urban population in 1700, the returns on cereal production in 1815, life expectancy and the 0-5 year mortality rate in 1806-1810. If the printing press had a positive influence on the development of a high share of municipalities, one would expect to find a positive correlation at the level of departments. Therefore, its influence seems to have been limited to, at best, the biggest towns of the country without influencing significantly the pre-19th century growth of the other municipalities.

[44]See Table A7 in the Appendix.

Table 6: Printing press and department characteristics. OLS and Tobit estimations

	(1) Tobit	(2)	(3)	(4)	(5) Tobit	(6)	(7)	(8)
	Urban population 1700	Returns on cereals 1815	Life expectancy 1806-1810	Mortality rate 0-5 years 1806-1810	Urban population 1700	Returns on cereals 1815	Life expectancy 1806-1810	Mortality rate 0-5 years 1806-1810
Printing presses within 150kms	-1.012	0.199	-0.234	0.002	–	–	–	–
	(-0.564)	(1.153)	(-0.757)	(0.610)				
Distance to printing press (kms)	–	–	–	–	-0.006	-0.001	-0.029	0.0004
					(-0.033)	(-0.088)	(-0.993)	(1.063)
Surface area	-0.000	-0.000	-0.000***	0.000***	-0.000	-0.000	-0.000**	0.000**
	(-1.644)	(-0.990)	(-2.888)	(2.728)	(-1.425)	(-0.951)	(-2.171)	(2.013)
Altitude	-0.070***	-0.001	-0.009***	0.000***	-0.073***	-0.001	-0.009***	0.000***
	(-2.958)	(-0.776)	(-2.915)	(2.969)	(-3.099)	(-0.466)	(-3.093)	(3.108)
Dep. with printing press	23.579**	0.228	2.091	-0.028	21.937	0.351	-0.321	0.004
	(2.615)	(0.264)	(1.343)	(-1.391)	(1.375)	(0.237)	(-0.122)	(0.129)
Male literacy - 1686-1690	–	0.114***	0.155***	-0.002***	–	0.124***	0.139***	-0.002***
		(3.960)	(2.976)	(-2.968)		(4.419)	(2.787)	(-2.824)
Observations	84	75	75	75	84	75	75	75
Left-censored observations	39				45			
Uncensored observations	45				39			
R^2		0.254	0.283	0.281		0.240	0.287	0.289
Pseudo-R^2	0.040				0.040			

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: *Statistique générale de la France*, IGN data, [ISTC, 1998] and [Febvre and Martin, 1999]. Life expectancy and morality rate from [Bonneuil, 1997]. Urban population in 1700 is provided by [Lepetit, 1988]. Returns on cereals are computed from the *Archives statistiques du Ministère des travaux publics de l'agriculture et du commerce*.

Notes: The unit of analysis is the department. The administrative centre of departments, the *préfecture*, was taken as the point from which distances were measured for each unit of analysis.

5.3 IV Outcomes

The second stage estimation equation is the following :

$$Dev_m = \alpha + \beta_1 Educ_m + \beta_2 Demo_m + \beta_3 Eco_m + \epsilon_{m,arr} \tag{3}$$

where Dev stands for the economic development of municipalities in 1881 or 1911 and where $Educ$ in instrumented by the printing press variables. In Table 7, I estimate the effect of primary education on the log of municipal resources in 1881 using both instruments. The Sanderson-Windmeijer *F-stat* is superior to ten in three cases over four, which tends to exclude the issue of weak instrument. This also prevents the estimations to be greatly biased if the printing press was even slightly directly correlated with economic resources [Bound et al., 1995]. However, using both instruments performs moderately well when focusing on the impact of enrolment on municipalities less than 1 109 inhabitants (the bottom 75%). This is why I will also use each instrument separately. The Hansen J p-value is superior to 10% in each case, which gives more credit to the exogeneity of the instruments used.

Outcomes indicate that one more year of primary schooling in a given municipality was associated with a 18.2% increase in economic resources using the IV strategy, 5% using the simple OLS. A one-percent increase in enrolment was linked to an increase in resources of around 0.5% when focusing on municipalities less than 1 109 or 1 935 inhabitants (bottom 75% or 90%), 0.6% for the more populous ones. Again, OLS estimates are lower, with a magnitude around 0.14% and 0.28%. IV estimates correspond to an increase of around 0.22 francs per capita for a 10% increase in enrolment and of around 0.8 francs per capita for an additional schooling year.

In all estimations, the IV estimates are superior to the OLS ones. This is most likely due to the

fact that there may be strong measurement errors in schooling years and enrolment rates which the IV estimations help to correct. Indeed, this information has been collected by inspectors within each primary school in a limited amount of time. This may have created approximations in the evaluation of primary schooling achievements[45].

Moreover, within primary schools located in small municipalities, pupils were often attending school quite erratically. It was common for example to see them one year in class and not the following. Indeed, their labour-force was often needed to ensure the financial stability of the family. Roughly speaking, only a small number of pupils were attending schools all year long and were not likely to be diverted from it by any other productive need, especially agricultural, that would require their participation [Furet and Ozouf, 1977b], [Mayeur, 2004]. In bigger towns, enrolment was more likely to be stable as families had on average higher economic resources to be dedicated to primary education. Since most of the municipalities in France were relatively small in 1833, 90% less than 1 935 inhabitants in my database[46], the issue of measurement error could have been indeed strong. Teachers or city mayors were more likely to make cruder approximations of schooling years and enrolment rates in these small municipalities where they were varying more, which explains why the IV estimates are above the OLS ones. The magnitude of the difference between the two is, as expected, higher in smaller municipalities when computing the effect of enrolment rates.

[45] Measurement errors have been evaluated to account for around 10% of the difference between OLS and IV estimates in the individual schooling/earning relation [Card, 1999]. However, here, this difference is likely to be much higher due to the less precise information conveyed by historical data compared to contemporaneous ones.

[46] For the entire country, this level is around 1 637 inhabitants.

Table 7: OLS and IV estimations - Schooling years, enrolment and municipal resources

	Log of municipal resources, francs per capita - 1881							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.050***	0.182***	–	–	–	–	–	–
	(4.636)	(3.269)						
Log of enrolment	–	–	0.125***	0.460***	0.140***	0.467***	0.282***	0.663***
			(4.461)	(3.159)	(4.982)	(3.502)	(7.809)	(3.931)
Population dispersion	-0.009***	-0.005**	-0.006***	-0.002	-0.007***	-0.003	-0.011***	-0.007***
	(-9.795)	(-2.317)	(-7.290)	(-1.032)	(-8.276)	(-1.570)	(-10.701)	(-3.389)
Population	-0.0004***	-0.0005***	-0.001***	-0.001***	-0.001***	-0.001***	-0.0001***	-0.0001***
	(-7.866)	(-7.676)	(-9.662)	(-8.629)	(-10.252)	(-10.322)	(-4.710)	(-3.305)
Surface area	0.001**	0.001***	0.001***	0.002***	0.001***	0.001***	0.0004***	0.001***
	(2.485)	(2.710)	(3.764)	(3.952)	(3.846)	(4.143)	(2.843)	(2.944)
Altitude	-0.001***	-0.0005**	-0.001***	-0.001***	-0.001***	-0.001***	-0.000*	-0.0004*
	(-3.011)	(-2.243)	(-3.648)	(-2.895)	(-3.519)	(-2.895)	(-1.884)	(-1.837)
Population growth - 1793-1836	0.000	0.000	-0.000	-0.000	-0.000	-0.000	0.000	0.001
	(0.378)	(0.582)	(-1.274)	(-0.367)	(-1.511)	(-0.650)	(0.757)	(1.119)
Distance to post office	-0.005*	-0.003	-0.007***	-0.007*	-0.005*	-0.004	-0.002	-0.000
	(-1.921)	(-0.781)	(-2.640)	(-1.714)	(-1.758)	(-1.323)	(-0.495)	(-0.013)
Postal taxes	0.0002***	0.0002***	0.0005***	0.0003***	0.001***	0.0004***	0.0001***	0.0001***
	(3.920)	(4.321)	(3.178)	(2.762)	(3.939)	(3.444)	(3.398)	(3.181)
Industrial production	0.000	-0.000	-0.000	-0.000	0.000	0.000	0.0001**	0.000
	(0.432)	(-1.016)	(-0.308)	(-0.764)	(0.491)	(0.383)	(2.107)	(0.718)
Distance to prefecture	-0.003	-0.003	-0.003*	-0.003	-0.003*	-0.003	-0.001	-0.002
	(-1.534)	(-1.247)	(-1.682)	(-1.190)	(-1.673)	(-1.297)	(-0.469)	(-1.118)
Latitude	0.096***	0.073***	0.120***	0.088***	0.102***	0.075***	0.002	0.021
	(4.873)	(2.784)	(5.731)	(3.072)	(5.178)	(2.919)	(0.098)	(0.953)
Dep. with printing press	0.422***	0.485***	0.400***	0.496***	0.416***	0.498***	0.386***	0.371***
	(5.175)	(4.694)	(5.112)	(4.780)	(5.474)	(5.159)	(4.929)	(4.655)
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Distance to printing press		-0.010***		-0.004***		-0.003***		-0.001
		(-7.31)		(-4.96)		(-5.39)		(-0.91)
Printing presses within 100kms		0.510***		0.191***		0.195***		0.168***
		(13.61)		(11.41)		(13.16)		(7.76)
Observations	5479	5479	4409	4409	5176	5176	1126	1126
R^2	0.581	0.430	0.581	0.404	0.590	0.440	0.564	0.449
$F-stat$		13.923		7.563		10.012		15.646
Hansen J p-value		0.160		0.135		0.115		0.240
Clusters	85	85	83	83	85	85	81	81

t statistics in parentheses

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

The number of printing presses within 100kms seems to be the most effective driver of primary schooling achievement. Indeed, in Table 7, one may see that the distance to the nearest printing press is not significant in the first stage for big towns. This can be easily understood since bigger cities were more likely to develop primary schooling, either located close or far from a town with a printing press. One printing press in the surrounding area was not likely to make a big difference. However, a higher number of printing presses could have favoured even more the

extension of written culture and of primary schooling. This accounts for the positive association between the number of presses, enrolment and schooling years in 1833. Therefore, I only use this instrument in Table 8[47]. The magnitude of the outcomes between the two tables is very close. The instrument is now strong in all specifications, which reinforces the reliability of the IV estimates. I also add in this table a *regression based p-value*[48], which is always inferior to 5%. The potential exogeneity of the primary schooling variables is therefore rejected. This argues for the use of IV estimations.

Table 8: OLS and IV estimations - Schooling years, enrolment and municipal resources

	Log of municipal resources, francs per capita - 1881							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.050***	0.160***	–	–	–	–	–	–
	(4.636)	(2.843)						
Log of enrolment	–	–	0.125***	0.397***	0.140***	0.412***	0.282***	0.648***
			(4.461)	(2.861)	(4.982)	(3.176)	(7.809)	(3.834)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Printing presses within 100kms		0.625***		0.228***		0.231***		0.178***
		(19.86)		(15.78)		(18.55)		(10.18)
Observations	5479	5479	4409	4409	5176	5176	1126	1126
R^2	0.581	0.243	0.581	0.264	0.590	0.262	0.564	0.285
$F-stat$		21.302		12.077		16.203		29.876
Regression-based p-value		0.015		0.020		0.013		0.012
Clusters	85	85	83	83	85	85	81	81

t statistics in parentheses

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

Interestingly, when computing the same estimations for the 1911 year, I still find a significant and positive impact of education, but with a lower magnitude. The effect of one additional schooling year is close to 10%, the one of enrolment to 0.25% for small municipalities[49]. As a consequence, the impact of primary schooling seems to have been at work before 1881. Between this date and World War I, municipalities characterised by early higher educational achievements still had more economic resources per capita. However, primary instruction didn't con-

[47] Using only the distance to the nearest printing press actually leads to similar outcomes. However, the instrument remains weak for big towns. See Table A8 in the Appendix.

[48] It relies on a test robust to clustering developed by Wooldridge.

[49] See Table A9 in the Appendix.

tribute significantly to increase these resources between the two periods. This point will be further discussed in Section 7.

These results remain significant under several robustness checks. Firstly, one may fear that excluding cities with the printing press from the analysis would be insufficient to ensure that the exclusion restriction holds. To go further on this point, I implement two restrictions on the data. First, I exclude municipalities less than 13 kilometres (5%) and more than 133 kilometres (also 5%) away from location of the printing press in 1500. This eliminates potential outliers that could drive the estimations, typically municipalities far away from the printing press, with no presses around them, no primary education and low economic resources. Also, it reinforces the reliability of the exclusion restriction by letting aside municipalities that could have benefited from economic spillovers from towns with a printing press. All estimates remain significant, with a slightly lower magnitude since one additional year of schooling is now associated with a 12.6% increase in economic resources. A 1% increase in enrolment raises resources by around 0.3%[50].

One additional robustness check on this point consists in excluding more municipalities that could have benefited from economic spillovers. I run the same estimations but keeping only the municipalities more than 35 kilometres away from the printing press, which amounts to letting aside the 25% closest to the press. One again, this doesn't modify the outcomes which remain very close to the general case[51]. The estimations computed using the number of printing presses within 100kms are therefore not highly dependent on the municipalities close to the printing press, which reinforces the strength and reliability of this instrument.

These results are also robust to the selection of different radii to compute the number of printing presses. Using a 75kms or 150kms radius doesn't alter the significance of the estimates[52]. The magnitude of the outcomes is higher when using the 150kms radius compared to the 75kms one, especially for big towns. This is most likely due to the loss of precision caused by the use of this instrument as printing presses located far away from municipalities are now entering the instrument. Standard errors associated to schooling years and enrolment are indeed higher in this case.

Moreover, the effect of schooling years remains significant when separating municipalities with the same population intervals as for enrolment rates. The magnitude of the effect is somewhat higher for bigger towns, as is the impact of enrolment. Using either distance to the nearest printing press or the number of printing presses within 100kms as an instrument returns significant results. The distance instrument is however less precise and powerful, as noted before, especially for big towns[53].

Finally, the effect of primary schooling on the development of municipalities is also robust to the control for spatial autocorrelation in the error term. I computed Conley standard errors [Conley, 1999] based on four different radii of 25, 50, 75 and 100 kilometres following the

[50] See Table A10 in the Appendix.
[51] See Table A11 in the Appendix.
[52] See Table A12 in the Appendix.
[53] See Table A13 in the Appendix.

methodology used in [Ashraf and Galor, 2011]. GMM estimations deliver significant results for any specification, whether considering municipalities in the bottom 75% or top 25% in terms of population level[54].

5.4 The Within-Department Effect

When studying the effect of education on the economic development of municipalities, it is interesting to keep only the within-department variation. Indeed, if municipalities with higher educational achievements had also higher economic resources, this may not have been the case in all departments. The results may therefore be driven by some of them, most likely the north-eastern ones where primary education was the most developed. I introduce department fixed effects in Table 9 to check for this differentiated impact. Finding a significant association between education and development after this introduction would be reassuring. Indeed, it would mean that the previous estimations are not driven only by a few departments and by potential omitted variables positively correlated to both education and future growth within them. Also, I separate the estimations according to the median ratio of municipalities with primary schools within departments[55]. The idea behind this is that primary schooling may have contributed differently to the economic development of a municipality depending on the educational performance of the surroundings areas.

I find that education was indeed influencing significantly economic development, but only in the eleven departments with a relatively low level of educational achievement. These departments are the following: Cher, Corrèze, Cotes d'Armor, Finistère, Indre, Indre et Loire, Loire Atlantique, Lozère, Morbihan, Nièvre and Saône et Loire. Within these departments, one additional year of schooling was on average associated with a 8% increase in economic resources in 1881. A one-percent increase in enrolment was linked to a 0.3% increase in resources. The instrument used becomes weak when working on departments well-endowed in primary schools. The impact estimated is only reliable for enrolment in municipalities less than 1 109 inhabitants. However, this coupled with the absence of significant results using the OLS is at least an indication that primary schooling was not significantly associated with economic growth within these departments.

Therefore, when primary education was well spread between municipalities, a higher enrolment or number of schooling years was not significantly influencing economic development. This was actually to be expected. Indeed, I showed in another work that municipalities in the north-eastern part of France were characterised by a higher presence of primary schools, but also that enrolment was on average higher in these departments, pupils attending schools for a longer number of years and learning more subjects [Montalbo, 2019]. Therefore, since education was more homogeneously developed in the departments above the Saint-Malo/Geneva line, it is logical not to find any significant influence of education when focusing on this area and adding

[54] See Table A14 and Table A15 in the Appendix.

[55] I don't cluster standard errors at the district level in the estimations. Indeed, the number of clusters would be too low to be reliable [Angrist and Pischke, 2008]. Robust standard errors are therefore computed instead.

department fixed effects.

In departments endowed with a low presence of primary schools, the variations in educational attainment were sufficiently high to impact the economic development of municipalities. Moreover, the restriction to cities below 1 109 inhabitants for enrolment and schooling years demonstrates that their effect was not driven by the higher educational achievement of big towns. This constitutes an additional indication that primary instruction impacted positively economic growth and that its effect was not confounded with or driven by the one of past economic resources.

Table 9: OLS and IV estimations - Schooling year, enrolment and municipal resources within departments

	Log of municipal resources, francs per capita - 1881											
	Deps. with % muncipalities with schools < median						Deps. with % muncipalities with schools > median					
Population intervals	Bottom 75%				Top 25%		Bottom 75%				Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Schooling Years	0.020***	0.088***	–	–	–	–	0.002	0.006	–	–	–	–
	(3.154)	(2.795)					(0.707)	(0.074)				
Log of enrolment	–	–	0.045***	0.290***	0.094***	0.303**	–	–	0.005	0.015	0.095**	0.045
			(3.117)	(2.808)	(3.404)	(1.991)			(0.594)	(0.118)	(2.456)	(0.129)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**		**Enrolment rate**				**Schooling years**		**Enrolment rate**			
Printing presses within 100kms		0.458***		0.143***		0.115***		0.112*		0.073***		0.080*
		(7.33)		(6.02)		(4.32)		(1.90)		(3.20)		(1.82)
Observations	1513	1513	1538	1538	770	770	2860	2860	2871	2871	356	356
R^2	0.654	0.299	0.652	0.218	0.655	0.321	0.694	0.322	0.696	0.358	0.613	0.387
$F-stat$		54.154		36.538		18.972		3.636		10.304		3.456
Regression-based p-value		0.013		0.007		0.143		0.963		0.938		0.888

t statistics in parentheses

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres. Departments below the media level are: Cher, Corrèze, Cotes d'Armor, Finistère, Indre, Indre et Loire, Loire Atlantique, Lozère, Morbihan, Nièvre and Saône et Loire. Departments above the median level are: Ardèche, Ardennes, Gard, Gers, Loiret, Marne, Oise, Seine et Marne, Deux Sèvres and Vaucluse.

6 Education Quality and Economic Development

A significant part of the education economics literature focuses on the effect of teaching quality on the volume of knowledge learnt. This quality, positively related to educational achievement [Rockoff, 2004], [Rivkin et al., 2005], has been proxied by several variables. Class size is one of them [Angrist and Lavy, 1999]. Teachers' salary has also been shown to influence positively test scores, whether at the country [Dolton and Marcenaro-Gutierrez, 2011] or at the school level [Nickell and Quintini, 2002], [Britton and Propper, 2016]. The main argument behind this influence is that higher salaries would attract better-qualified teachers [Figlio, 1997], their level of qualification being itself positively correlated with teaching quality [Behrman and Birdsall,

1983], [Ehrenberg and Brewer, 1994]. Salary may be the best proxy for quality [Hanushek and Rivkin, 2006], even if incentives within classrooms seems to play a major role in increasing teaching and educational achievements [Hanushek, 2003]. A higher quality, also proxied by pupil/teacher ratios, impacts positively individual earnings [Card and Krueger, 1992a], [Card and Krueger, 1992b].

In parallel with these microeconomic studies, the impact of education quality on growth also came under scrutiny. At the macroeconomic level, quality has been proxied by test scores, reflecting the cognitive skills' spread within the labour force. Quality is therefore to be understood here as an educational output, while it is an input in the microeconomic studies. Higher scores, often measured at the secondary or higher level, were shown to strongly influence economic growth within the 1960-2000 time period [Hanushek and Kim, 1995], [Hanushek and Kimko, 2000], [Barro, 2001], [Hanushek and Woessmann, 2012]. Also, both the share of people mastering basic skills, or the share of those performing highly in test scores seem to matter for economic growth [Hanushek and Woessmann, 2008].

Thanks to the information reported in the Guizot survey, I can provide some evidence about the relation between schooling quality and economic development in nineteenth-century France. A crucial difference between primary schools at that time was the potential financial support provided by municipalities to education. Indeed, teaching was a hard profession [Prost, 1968], especially when the school was private and only financed by schooling fees paid by families. In this case, the teacher could only rely on his own ability to attract a sufficient number of pupils so that he could benefit from a decent remuneration. If the teacher was not good enough to do so, he would often try his luck in another municipality [Meunier, 1981]. Also, without municipal support, teachers were forced to find a place to practice on their own. This could be their house in the best case, but also a barn in winter, the meadows during summertime [Lorain, 1837].

Municipalities could invest in primary education by hiring teachers for a year and providing them with a fixed salary. They could also grant them with an accommodation, a classroom (often a room in the town hall), or another municipal occupation. In this last case, they were offering the teacher to be paid on a regular basis if he would also serve as a mass cantor, a town clerk, or any occupation useful to the municipality. Therefore, municipal investment was increasing the financial stability of the teachers and improving their working conditions. In another work, I showed that this municipal investment was associated with the recruitment of better-qualified teachers, a higher teaching quality (as evaluated qualitatively by the inspectors from the Guizot survey) and higher educational achievements proxied by the average number of schooling years [Montalbo, 2019]. Descriptively, there was a positive association between the indicators of municipal investment and the future economic resources of municipalities. The resources of municipalities paying teachers were on average of 10.01 francs per capita in 1881, against 5.83 for those which didn't. The respective figures for the accommodation, other occupation provisions and second degree certificate are of 11.28 against 7.95, 10.63 against 6.54

and 9.58 against 7.80[56].

Therefore, in Table 10, I evaluate if better working conditions and a higher teaching quality were associated with an increase in municipal resources using OLS estimations. I only keep municipalities with a primary school in the estimations so that the effect of quality wouldn't be mingled with the influence of a primary school's presence. This approach is a mix between the micro and macro ones as it connects directly schooling inputs to economic resources. I introduce dummy variables indicating if the school was subsidised or not by the municipality in the estimations, along with the standardised salary provided to the teacher (only when he was granted with such a salary). I gather accommodation and classroom grants since they were only 88 cases of municipalities providing an accommodation but not classroom. Inspectors seem to have considered that when a teacher was provided with an accommodation, he could practice at home and was therefore also granted with a classroom.
I also evaluate the effect of teachers' certification level. From 1816 onwards, a certificate composed of three different degrees, the third one being the lowest on the hierarchy, was a prerequisite for teaching. The third degree could be obtained thanks to a minimum mastering of numeracy and literacy. With additional notions of spelling and calculus, they were likely to obtain the second degree. The first one was only accessible for teachers mastering grammar, land surveying, geography and arithmetic. I only introduce the second-degree certificate, obtained by around 38% of the teachers, in the estimations since nearly no teachers, around 1%, had obtained the first-degree one in 1833. Also, 6% of the teachers still didn't abide by the 1816 law and had no certificate in 1833. Therefore, the effect computed is of having a high-level certificate compared to a low-level one or to no certificate.
At the same level of education achievement in terms of schooling years and enrolment, municipalities which increased teachers' financial ease had higher economic resources per capita 50 years later. Providing teachers with a fixed salary was associated to a 12.7% increase in resources in 1881, one standard deviation in this salary with a 16.2% increase. Granting teachers with another municipal occupation was also positively linked to resources, with a magnitude around 8.5%. This is very likely to reflect the influence of schooling quality. The effect of the accommodation or classroom grant is more dubious and there is no significantly relation between resources and the certification level.

It would too bold to assert that these relations are causal. Municipalities with initial higher resources were more likely to invest in primary education and to be more developed at the end of the century. However, the controls on initial resources should account partly for this in the estimations. Moreover, controlling by enrolment improves this point. Indeed, on average, paying the schooling fees for one child amounted to spend between 1 and 1.2 francs per month. This was equivalent to the daily wage of an industrial female worker and between 50% and 71% of an industrial male daily wage. The agricultural survey of 1852 indicates the annual spendings and savings of a day-worker family with three children[57]. Assuming that one of them

[56]The difference between these figures is always significant at a one-percent level. See Table A16 in the Appendix.

[57]Those were clearly the poorest among agricultural workers since, for example, food represented between 57

was working and, depending on the hypotheses made on the attendance of the two children left (both 12 months, one 12 and the other 6 or both 6 months) schooling fees represented respectively 16, 21 or 26% of total savings. The fees were therefore a strong economic barrier to the schooling of children coming from destitute backgrounds. This why most of these families were not schooling their children and were sending them all to work [Villermé, 1829]. Therefore, municipalities where the same proportion of children were attending schools should not have been too far in terms of families' economic resources. As a consequence, schooling quality should explain a fair part of the association found between municipal investment and economic resources.

Table 10: OLS estimations - Public primary schooling and municipal resources

	1881					1911				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fixed salary	0.127***	–	–	–	–	0.086***	–	–	–	–
	(2.999)					(2.867)				
Fixed salary amount	–	0.162***	–	–	–	–	0.085***	–	–	–
		(5.417)					(3.260)			
Accommodation or classroom	–	–	0.067	–	–	–	–	0.068**	–	–
			(1.596)					(2.338)		
Other municipal occupation	–	–	–	0.085*	–	–	–	–	0.069*	–
				(1.869)					(1.886)	
2nd degree certificate	–	–	–	–	0.031	–	–	–	–	0.012
					(1.181)					(0.625)
Log of enrolment	0.305***	0.333***	0.317***	0.319***	0.320***	0.247***	0.245***	0.253***	0.255***	0.259***
	(6.786)	(6.659)	(6.764)	(6.608)	(6.725)	(5.833)	(4.793)	(5.901)	(5.866)	(5.997)
Schooling Years	0.025*	0.010	0.025*	0.023*	0.026**	0.026*	0.023	0.026*	0.025*	0.027**
	(1.952)	(0.725)	(1.988)	(1.797)	(2.063)	(1.945)	(1.531)	(1.938)	(1.859)	(2.009)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3031	1985	3031	2986	3031	3029	1983	3029	2984	3029
R^2	0.608	0.579	0.605	0.605	0.604	0.607	0.547	0.607	0.605	0.604
Clusters	76	73	76	76	76	76	73	76	7	76

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003].

Notes: The fixed salary amount effect is only computed for municipalities providing a fixed salary to the teacher. This variable is standardised. Other indicators of municipal investment are dummy variables equal to one if the grant at stake was provided to the teacher.

Quality is also likely to have influenced educational achievements, even with no increase in enrolment or schooling years. Indeed, the threat to lost municipal support was a strong incentive for teachers to invest in their work and improve their teaching quality. Therefore, if pupils were learning better all year long, they would maybe even have needed less time to master the basics of literacy and numeracy. Also, a better education was likely to have lasting effects on pupils through the accumulation of a more deeply-rooted knowledge[58]. In order to give further

and 79% of their annual spendings, with a mean of 66%.

[58]It was for example common for people, during their lifetime, to learn several times how to read in order to master it properly [Laqueur, 1976]. Teaching quality may have reduced this need to go over the same difficulties again and again.

credit to the association between quality and economic development, I now turn to a matching estimation technique [Rosenbaum and Rubin, 1983][59].

The idea here is to estimate a propensity score for municipal investment in education. Treated units, municipalities which did invest in primary schooling, are then matched with control units, municipality which did not, according to this score. Therefore, I let the certification variable aside. When using this technique, the choice of covariates is essential as matching relies on the unconfoundedness assumption, which states that treated units are selected on observables. Therefore, the assignment to treatment is supposedly independent of the outcomes, conditional on the covariates. In this case, it means that the decision of municipalities to subsidise schools could be fully explained by the selected covariates. Omitting important variables can seriously increases the bias in resulting estimates [Heckman et al., 1997], [Dehejia and Wahba, 1999]. Also, the covariates should influence simultaneously the future economic resources of municipalities and their propensity to subsidise primary schooling.

I selected the following set of covariates: log of enrolment, schooling years, population in 1833, population dispersion, surface area, the distance to post office, postal taxes, industrial taxes, the number of printing presses within 100kms. I also added the distance of municipalities to the cities of Lyon, Paris, Marseille, Nantes, Bordeaux, Strasbourg, which could have influenced their economic development. These variables should account for the economic resources of municipalities that enabled them to invest in education, as well as for the cultural influence that prompted them to do so. Also, the education covariates should reinforce the comparability of the matched observations whose educational differences rely only on municipal investment. In Figure 6, I represent the propensity scores associated to the municipal grants, estimated using a logit specification. There is a substantial overlap in the distributions for municipalities subsidising education and those which did not. This is essential for the econometric identification with the matching technique.

[59] See [Heckman et al., 1997] and [Dehejia and Wahba, 1999] for influential papers using the matching technique. See also [Lalonde, 1986] and [Smith and Todd, 2005] for a discussion about the reliability of this technique.

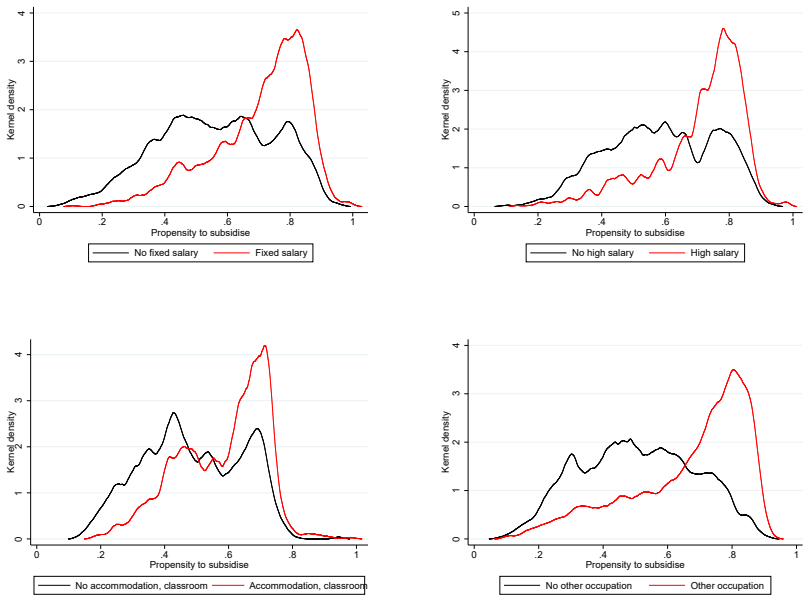


Figure 6: Propensity score densities

Source: Guizot, industrial, postal surveys, IGN data. [Motte et al., 2003] and *La Situation Financière des Communes*.

Note: Propensity scores for the municipal grants are displayed in these graphs.

In Table 11, I report the nearest-neighbour matching estimates on municipal subsidies[60]. In order to include the fixed salary amount, I created a dummy variable indicating if teachers were benefiting from a "high salary" or not. 50% of the municipalities providing a salary were paying teachers less than 200 francs a year. I took this median value as a threshold to build the variable[61]. The effects found are in compliance with the ones reported in Table 10. Providing teachers with an accommodation or a classroom had no influence on economic development. A higher financial support, embodied by a fixed salary, its amount, and another municipal occupation was positively related to the future resources of municipalities. As before, the effect is decreasing in time.

In order to give further reliability to these estimations, I checked that the covariates I use are balanced between the treated and control municipalities in the matched sample. I did so for the fixed salary provision and found no statistically significant difference in the average values of each covariate between the two groups. Moreover, the bias associated to the covariates between the groups [Rosenbaum and Rubin, 1985] is greatly reduced within the matched sample, from an average value of 16.9% to 2.6%[62]. Therefore, there is no issue of selection bias between the two groups in the matched sample.

Also, as a robustness check, I computed the same estimations using a nearest-neighbour matching, but adding restrictions on the propensity score. First, I restricted it to the common support.

[60]This, compared to taking several neighbours, has the advantage of minimising the bias associated with the matching estimation.

[61]In these estimations, I use the *teffects psmatch* command in Stata. This use is recommended for the computation of the standard errors of matching estimates. See [Abadie and Imbens, 2016] for example.

[62]These tests are computed using the *psmatch2* command in Stata.

Second, I restricted the selection of neighbours using a caliper bounded to 0.2 standard deviation of the propensity score, as recommended in [Austin, 2011] for minimising the bias related to the estimations. This didn't alter the outcomes for what regards their significance or the magnitude of the estimates[63].

Table 11: Matching estimations - Public subsidies and log of municipal resources, francs per capita

	1881				1911			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fixed salary	0.186***	–	–	–	0.119***	–	–	–
	(4.975)				(5.058)			
High salary	–	0.104**	–	–	–	0.079**	–	–
		(2.518)				(2.204)		
Accommodation, classroom	–	–	0.014	–	–	–	0.036	–
			(0.497)				(1.526)	
Other occupation	–	–	–	0.108***	–	–	–	0.075**
				(2.782)				(2.229)
Observations	3047	2041	3047	3002	3046	2039	3046	3001

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys, IGN data. [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: All variables are dummy ones, indicating if the municipality at stake was subsidising primary education. The *High salary*, variable is equal to one if the municipality was paying the teacher more than 200 francs per year, which is the median fixed salary level.

7 Transmission Channels

Why did primary education contribute to the economic development of municipalities ? Was there an unsatisfied demand for academic skills that would explain the higher economic performance of municipalities where education was more developed ? Was this due to another phenomenon, for example migrations which were so pronounced in the second part of the 19th century ? In the literature on education, there are three main transmission channels identified between education and growth. Firstly, education increases the accumulation of human capital in the labour force, then productivity and the level of output. This is the channel describes in the neoclassical models [Mankiw et al., 1992]. Secondly, education may increase the innovation capacity of the economy. The new technologies, products and processes then contribute to promote growth. This is the channel advocated by the endogenous growth theorists [Lucas, 1988], [Romer, 1990]. Last but not least, education can facilitate the diffusion and transmission of knowledge and new information, helping to implement successfully new technologies which could be devised by others. This contributes to enhance economic growth [Nelson and Phelps, 1966], [Easterlin, 1981].

[63] See Table A18 in the Appendix.

Before discussing the channels, it is interesting to point out that primary schooling positively influenced the level of economic resources both in 1881 and 1911, but that it didn't enhance growth between these two dates. Municipalities with an early well-developed primary education grew at a lower rate during this period. Descriptively, the presence of a primary school in 1833 was associated with a growth of economic resources around 115% between 1881 and 1911, against 143% in municipalities without schools in 1833[64]. Therefore, the positive impact of primary education was mainly concentrated from the beginning of the century to the 1880s, during the period of high growth. This indicates a progressive convergence between municipalities towards the end of the century. The results is coherent with studies showing that a convergence in primary schooling took place in nineteenth-century France, even before the Ferry Laws of 1881-1882 which made primary education mandatory [Diebolt et al., 2005]. As shown in Table 9, primary schooling was less likely to influence significantly the growth of municipal resources when it was relatively well-spread across all municipalities. The Ferry Laws certainly dealt the fatal blow to the impact of primary education on development, as it has been the case in the early 1870s in England [Mitch, 1984].

Among the transmission channels, the second one may be the easiest to discuss and reject as it mostly applies to countries. Indeed, it is highly unlikely that variations in enrolment rates and in the number of years spent within primary schools conducted some municipalities to benefit from a higher innovation rate than others. More people mastering literacy and the basics of numeracy, or even with a secondary education, was not leading to more innovations. In the American and British cases, it has been shown that inventors of the nineteenth century didn't perform particularly well in terms of educational achievement [Khan and Sokoloff, 1993], [Khan and Sokoloff, 2004], [Khan, 2018]. The third transmission channels seems to bear more explaining power for what regards the link between education and technological progress.
Indeed, more education people may have been less reluctant to implement new technologies, to use new tools or to adopt new production processes. A good example illustrating this point is the "green revolution" in India. It has been shown that rural households with at least one adult with a primary education were more likely to use the high-yielding variety seeds introduced in the late 1960s. This in turn contributed to increase thee returns to schooling, especially in areas with higher past growth rates [Foster and Rosenzweig, 1996]. Either more educated people used earlier these seeds or they used them better. In this perspective, technology is therefore more likely to increase growth when the initial level of instruction is higher. This has also been studied in the case of American agriculture in the late 1950s [Welch, 1970] and manufacturing industries between 1960 and 1980 [Bartel and Lichtenberg, 1987][65].
This is very likely to have been valid for France during 19th century, especially in the agricultural sector. Indeed, the implementation of innovations in industry, which multiplied from the

[64]OLS and IV estimations exhibit this negative association between primary schooling and the 1881-1911 growth rate of municipal resources. See Table A19 in the Appendix. The estimates' magnitude is high, but in line with the descriptive statistics.

[65]This argument is also closely related to [Glaeser, 2003] and [Glaeser et al., 2004] who show that human capital influenced strongly the growth of cities when economic (technological) shocks were affecting them, thanks to the higher "ability to deal with disequilibria" of people [Schultz, 1975].

1830s onwards, were certainly more dependent on the location of natural resources and on the economic resources of manufacturers. It is true that tradition and the fear of making useless investments may have deterred the diffusion of innovation in industry, but most likely to a lesser extent. The location of steam engines for example, whose number jumped from 150 to 6 000 between 1816 and 1850, was highly dependent on the presence of coal and mines and therefore strongly concentrated in the north-eastern part of France [Woronoff, 1998]. Other important industrial innovations, as the Bessemer process invented in 1856 for the mass production of steel from molten pig iron, was implemented within big factories and had little to do with primary education. However, the diffusion of mechanised work in the textile sector disseminated through the French countryside was more likely to be linked to education. The water frame of Richard Arkwright or the spinning jenny of James Hargreaves could be implemented in small manufactures and at a relatively low cost. More educated manufacturers may have been more rapidly aware of the potential benefits they could draw from these innovations, and therefore more eager to implement them within their factories.

Within the agricultural sector, the spread of fertilizers, which began to surge in the second part of the century [Clout and Phillips, 1972], may have been facilitated by the proximity of farmers to the new agronomy. However, it is difficult to disentangle the effect of education from the one of income and soil composition. Indeed, this spread remained highly concentrated in the Paris basin during the 19th century. The adoption of innovations related to the plough also began in the richer and more educated areas in France. The adoption of the Dombasle plough in the 1820s and the progressive transition to the Brabant one at the end of the century followed this pattern [Beltran and Griset, 1994]. Many factors can have influenced the differentiated spread of the plough as the presence of horses as draught animals, the composition of the soil and cultivations, the purchasing power of farmers, ... But surely resistance to the introduction of new techniques played a significant role [Duby and Wallon, 1976]. Education may therefore have facilitated the early adoption of these techniques. The same is true for the transition from the sickle to the scythe, the introduction of the threshing machines in the 1860s and of the harrow, which took place firstly in the north and north-eastern parts of the country.

The first transmission channels mentioned, the increase in productivity, can explain economic development only if some jobs were better performed with a higher primary education, or if a higher educational achievement was enhancing the creation of more productive jobs. At first sight, the second reason seems to have been the more relevant historically. Indeed, even if the returns to schooling were likely to be high in the mid-19th century [Mitch, 1984][66], there was only a small share of jobs for which literacy was absolutely necessary. For instance, the 1841 census for England indicates that 4.9% of men and 2.2% of women had such an occupation. The respective percentages for jobs with no need of literacy were of 49.7% and 24.7% [Mitch, 1993][67].

In the case of industry, there is an ongoing debate about its impact and relation with education.

[66] As they are for example today for developing countries, higher than the returns to secondary or higher education [Psacharopoulos and Patrinos, 2004].

[67] See also [Galor and Moav, 2006] on this point.

Supporters of the "deskilling hypothesis" [Sanderson, 1972], [Nicholas and Nicholas, 1992] argued that early industrialisation and the progressive introduction of large-scale factories using steam-power were mainly skill-saving, favouring the development of low-skilled jobs [de Pleijt and Weisdorf, 2014], [de Pleijt, 2018]. This was especially true if steam engines were favouring the use of machines on which children were performing secondary tasks in assisting older workers, as putting together broken pieces of thread on spinning mules in the textile sector [Nardinelli, 1980], [Nardinelli, 1990], [Humphries, 2012]. In the Nord department, for example, industrial districts were found to be characterised by relatively low literacy rates between 1831 and 1843 [Leblond, 1970]. By the same token, the presence of a developed textile sector was correlated with a lower literacy in the diocese of Rouen at the end of the 18^{th} century [Furet and Ozouf, 1977b]. However, showing that industry led to a fall in literacy is not obvious [Schofield, 1973], [Corbin, 1975], [de Pleijt et al., 2016]. In the case of France, there seems to have been a complementarity between technology and human capital [Franck and Galor, 2017]. Similarly, Diebolt et al., 2017a found that the number of steam engines within departments was positively associated with literacy rates and primary schools' presence in the first part of the nineteenth century. They interpret this as being due to the fact that basic knowledge was required in industry in the first part of the century, while a more upper-tail one became complementary to industrial activities in the second part. In another work, I showed that industrial activities influenced positively primary schooling through an income effect on municipal resources, but that they didn't increase significantly the accumulation of human capital within primary schools [Montalbo, 2018].

Still, one has to remember that higher enrolment rates and primary schooling years were often synonymous with more people knowing how to read and write and the basics of numeracy. This very simple improvement in education may have increased the productivity in many jobs. A higher capacity to keeping accounts for example, or the possibility to find somebody nearby able to do so, was certainly useful for merchants, bakers, butchers, ... and all people who had at some point to deal with numbers or contracts. Moreover, the demand of literate people increased also in industry during the second part of the century, notable with the need of reading plans [Mitch, 1993]. Finally, and maybe to a lesser extent, manufacturers might have looked for a more disciplined workforce likely to be more productive and less often absent from work [Johnson, 1970], [Rosanvallon, 1985].

Primary education may also have favoured the concentration of more productive people and jobs. Literate and more skilled parents can for example have decided to migrate to a given municipality where primary schooling was well-developed because they had a higher preference for education. This Tiebout sorting [Tiebout, 1956] would have reinforced the positive effect of education on economic resources by gathering more productive people. Moreover, if past education helped developing attractive jobs requiring more skills, these people would also have migrated in order to seize these better working opportunities. Generally speaking, numerous studies have shown that more educated people were migrating farther away in the 19th century [Heffernan, 1989] [Hoyler, 1998], [Rosental, 2004], [Bonneuil et al., 2008]. Scholars have

insisted on the idea that job opportunities were guiding these migrations. Also, education was facilitating migration by increasing the network and communication means of migrants. Migrations from villages to villages which were numerous before the 1880s [Rosental, 1994] were also greatly dictated by education [Rosental et al., 2000]. Therefore, instruction may have influenced the concentration of skill-demanding jobs, this in turn attracting more educated people who reinforced the productive advantage of the municipalities. This cumulative effect is likely to have played an important role in explaining the differentiated economic development of municipalities.

Moreover, the presence of more educated people has certainly played a role on the economic performance of adults living in the same municipality [Marshall, 1890], [Moretti, 2004a], [Moretti, 2004b][68]. Localised educational spillovers may have taken different forms: a positive influence on co-workers' performance in a given plant, a higher agricultural production influencing nearby farmers to adopt the same technology and techniques, a simple gesture of solidarity as helping another inhabitant with a complicated tasks, ... Also, the growth of British cities between 1861 and 1961 has been influenced by the composition of their labour-force. A higher concentration of business professions producing and transmitting information[69] helped increasing economic efficiency [Simon and Nardinelli, 1996]. This might have also influenced the development of bigger towns in the French case.

8 Conclusion

Major economic and social events of the 19th century have left a lasting mark in French history. First, the alternation of political regimes resulted in the advent of the republican system. Second, this period was characterised by the industrialisation of the country, along with the progressive modernisation of the agricultural sector. Primary education also developed strongly during this century, in link with growing economic resources and a higher demand for academic skills on the labour market. Important laws also sustained this extension by increasing the supply of schools. The Guizot law of 1833 initiated this movement by making mandatory for municipalities more than 500 inhabitants to open and fund a primary school for boys. Then, the Falloux and Duruy laws of 1850 and 1867 extended this legislation to girls. Finally, compulsory schooling was enacted by the Ferry laws of 1881 and 1882.

Primary education spread was spatially differentiated between French departments and municipalities before 1833. Some areas, as the north and north-eastern parts of the country, were already characterised by high educational achievements in the early 19th century. This educational edge played an important role in the subsequent development of the municipalities.

Indeed, whether using a regression discontinuity estimation technique around the 500-inhabitant threshold created by the Guizot law, or instrumenting primary education by the long-term establishment of printing presses lead to the same conclusion. Municipalities where an early

[68]The evaluation of the external effects of education have been debated. See for example [Acemoglu and Angrist, 2000] for a counter-example.

[69]Namely: bankers, brokers, insurance agents, accountants, auctioneers and commercial travellers.

investment in primary schooling was present, either by families alone or with the financial assistance of local authorities, had a higher level of economic resources per capita at the end of the 19th century and just before World War I. Schooling quality, proxied by the municipal investment in schools, also influenced positively municipal development. Therefore, it is within municipalities where education was well-developed and public that the effect of primary schooling on economic development was the strongest.

This positive effect of education on growth was concentrated before the end of the century. The progressive educational convergence between municipalities contributed to diminish its impact. Primary schooling appears to have been an important factor in explaining the growth of municipalities during the century of industrialisation and modernisation in France. Several transmission channels may account for this positive impact. The quicker adoption of new and more productive techniques in the agriculture is one of them. The concentration of more productive people and jobs through migrations is another. These two are the most plausible factors behind the association between education and development in nineteenth-century France.

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Appendix for on-line publication

Data and descriptive statistics

Table A1: Data representativeness, means and t-tests

	France	Municipal level sample	t-test
Population - 1833	91 948	85 794	NS
Number of municipalities	105	90	***
Percentage of population scattered	49.4	55.4	*
Average altitude - meters	300	211	***
Surface area - hectares	1 566	1 869	***
Percentage of municipalities with schools	71.5	60.8	***
Primary schools per 100 municipalities	215	79	NS
Teachers with a fixed salary per 100 municipalities	48.1	51.9	NS
Teachers with an accommodation per 100 municipalities	43.6	46.8	NS
Pupils per 100 children and single people	19.9	16.5	**
High heights among conscripts (%)	32.5	30.2	*
Percentage of municipalities with factories	17.2	21.6	**
Percentage of municipalities with factories $>$ 20 workers	7.6	8.3	NS
Number of industrial workers	3 592	2 531	NS
Industrial male worker daily wage - cents of francs	192	187	NS
Taxes on industrial activities - francs per year	12 733	12 591	NS
Total agricultural area - hectares	143 903	150 892	NS
Land value by hectare - francs	1 825.6	1 644.5	**
Food % in day-workers family spendings	66.4	66.5	NS
Male day-workers daily wage - francs	1.42	1.38	NS
Female day-workers daily wage - francs	0.89	0.87	NS
Day-workers per 100 self-employed	103.6	111.1	NS
Share-croppers per 100 self-employed	10.3	10.9	NS
Tenant farmers per 100 self-employed	16.8	27.8	***

*** p<0.01, ** p<0.05, * p<0.1.

Source: Guizot, industrial, agricultural and postal surveys. IGN data and [Motte et al., 2003]. Military data on conscripts from [Aron et al., 1972].

Notes: All figures are computed at the level of districts. The average population in each district was respectively around 85 794 inhabitants for those belonging to the municipality level sample and around 91 948 inhabitants for the entire France. The difference between the two is non-significant.

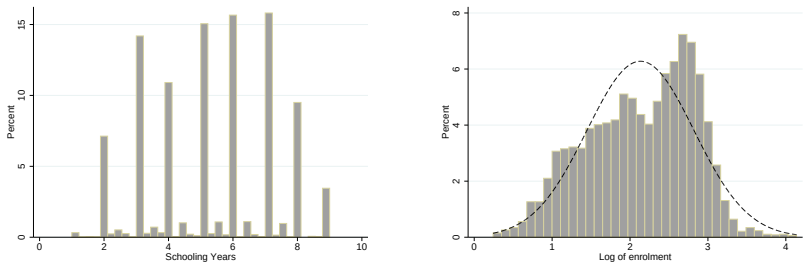


Figure B1: Histograms of enrolment and schooling years

Source: Guizot survey.

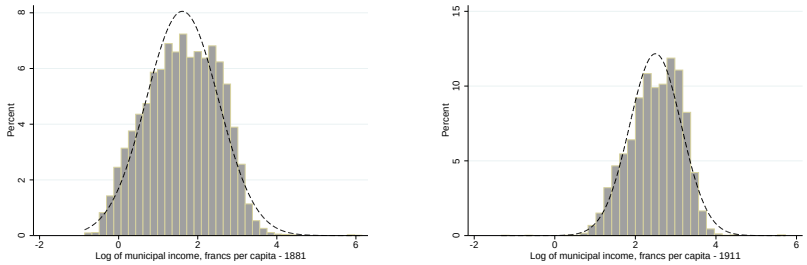
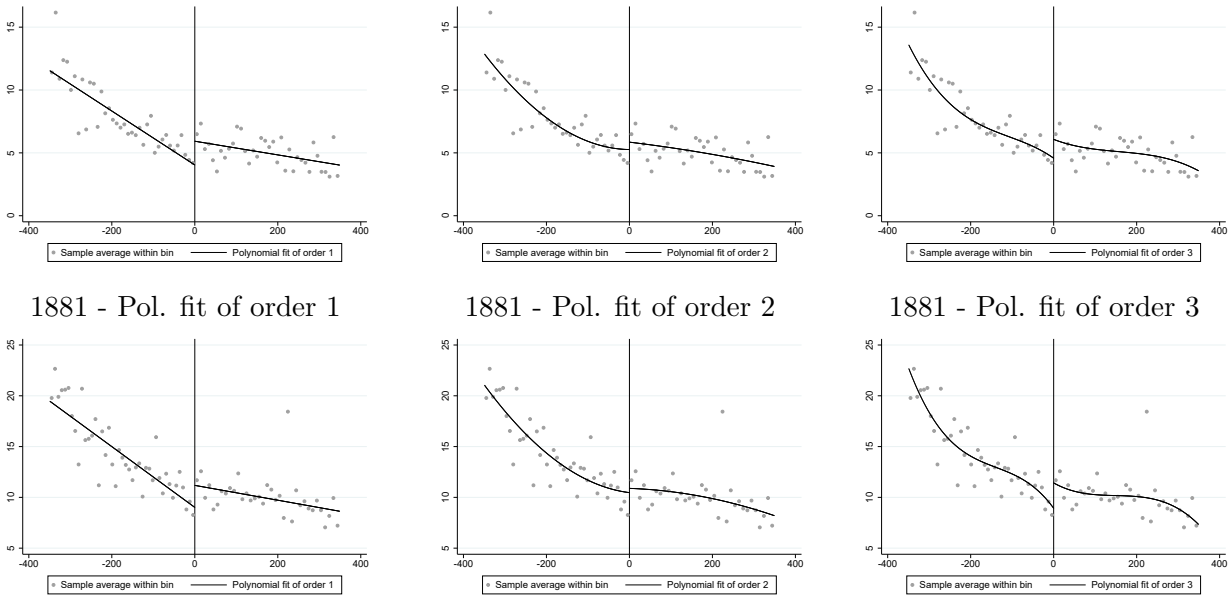


Figure B2: Histograms of the log of municipal resources, 1881 and 1911

Source:*La Situation Financière des Communes*.

Regression discontinuity design



1881 - Pol. fit of order 1 | 1881 - Pol. fit of order 2 | 1881 - Pol. fit of order 3

1911 - Pol. fit of order 1 | 1911 - Pol. fit of order 2 | 1911 - Pol. fit of order 3

Figure B3: Data-driven regression discontinuity in municipal resources per capita with different polynomial fits

Source: Guizot survey and *La Situation Financière des Communes*.

Notes: On the x-axis, the distance in terms of population to the 500-inhabitant threshold is displayed.

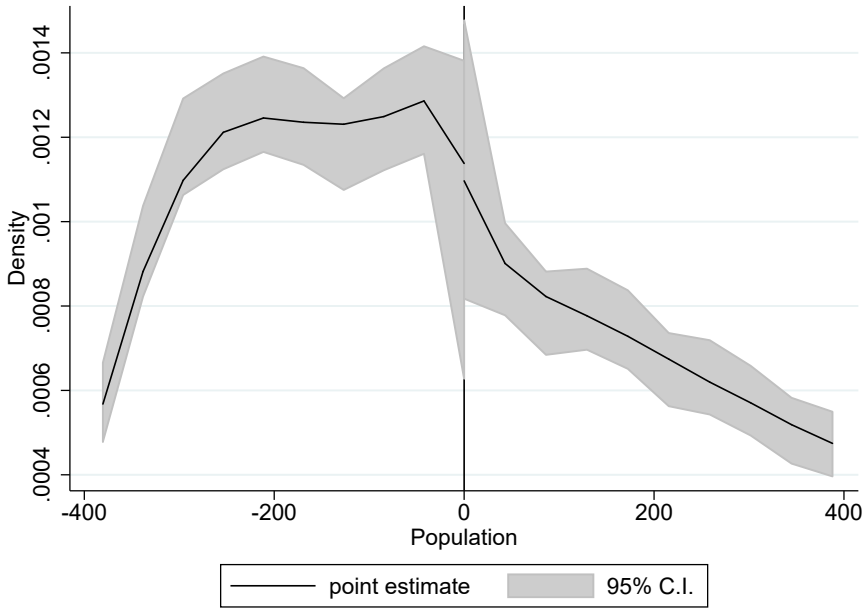
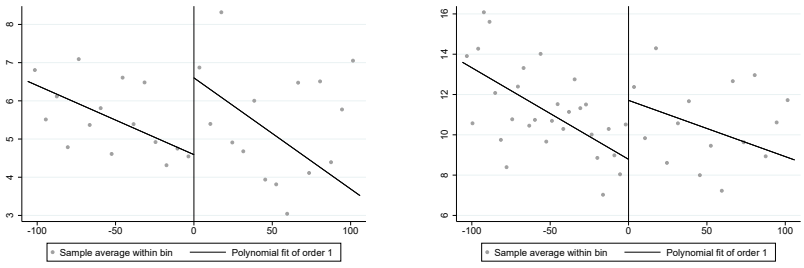


Figure B4: Population density around the 500-inhabitant threshold

Source: [Motte et al., 2003]

Notes: On the x-axis, the distance in terms of population to the 500-inhabitant threshold is displayed. The density of population and its 95% confidence interval are reported in grey.



1881 1911

Figure B5: RD plot of treatment effect

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: On the x-axis, the distance in terms of population to the 500-inhabitant threshold is displayed.

Table A2: Non-parametric regression discontinuity estimates with CER-optimal bandwidth - Municipal resources per capita

	1881				1911			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RD Estimate	2.778***	1.856***	2.928***	2.574***	4.115***	2.211***	2.605***	2.107**
	(2.97)	(3.14)	(3.44)	(3.15)	(3.23)	(2.62)	(2.90)	(2.07)
Controls	253	333	141	197	221	285	237	309
Treated Units	209	245	135	163	187	212	197	228
Covariates	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Left Clusters				67				72
Right Clusters				62				66
Kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Order Loc. Poly.	1	1	1	1	1	1	1	1
Order Bias	2	2	2	2	2	2	2	2
BW Loc. Poly.	70.91	105.9	49.57	65.67	60.46	90.31	79.02	98.17
BW Bias	188.5	188.5	142.4	148.1	170.3	170.3	218.5	219.4

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: The specifications in this table are the same as in Table 3. In columns (3) and (7), I add covariates which are incorporated in the computation of the optimal bandwidth. This is not the case in columns (2) and (6) where the covariates are added without entering in the computation of the optimal bandwidth. I cluster standard errors at the district level in columns (4) and (8).

Table A3: Non-parametric regression discontinuity estimates, other bandwidths - Municipal resources per capita

	1881					1911				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RD Estimate	3.059***	2.700***	2.010***	1.702**	1.501**	4.286***	3.781***	3.167***	2.554***	2.184***
	(2.77)	(2.97)	(2.63)	(2.40)	(2.32)	(3.08)	(3.28)	(3.00)	(2.74)	(2.58)
Controls	172	273	400	465	544	172	272	339	464	544
Treated Units	165	223	294	337	402	168	226	260	340	406
Covariates	No	No	No	No	No	No	No	No	No	No
Kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Order Loc. Poly.	1	1	1	1	1	1	1	1	1	1
Order Bias	2	2	2	2	2	2	2	2	2	2
BW Loc. Poly.	50	75	105.9	125	150	50	75	90.30	125	150
BW Bias	50	75	105.9	125	150	50	75	90.30	125	150

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: RD estimates on a choice of different bandwidths are displayed.

Table A4: Non-parametric regression discontinuity estimates - Continuity of covariates

	(1) Population dispersion	(2) Surface area	(3) Altitude	(4) Population growth 1793-1836	(5) Distance to post office	(6) Postal taxes	(7) Industrial production	(8) Distance to prefecture	(9) Latitude
RD Estimate	-1.871	12.73	-58.13	-12.85	-0.679	4.100	11.47	-3.110	-0.177
	(-0.34)	(0.81)	(-1.39)	(-1.46)	(-0.89)	(0.46)	(1.42)	(-1.18)	(-0.66)
Controls	405	411	411	419	425	433	433	411	382
Treated Units	285	301	301	305	293	310	310	301	279
Kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Order Loc. Poly.	1	1	1	1	1	1	1	1	1
Order Bias	2	2	2	2	2	2	2	2	2
BW Loc. Poly.	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9
BW Bias	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: RD estimates on covariates are displayed in order to check for the continuity around the 500-inhabitant population threshold.

Table A5: Non-parametric regression discontinuity estimates - Falsification tests

	Municipal resources per capita - 1881									
Population cutoffs:	200	300	450	550	700	800	1 000	1 300	1 600	1 900
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RD Estimate	-2.214	-0.646	0.312	-0.373	-0.655	0.196	0.364	0.418	-0.224	-0.223
	(-1.57)	(-0.64)	(0.45)	(-0.60)	(-0.80)	(0.32)	(0.59)	(0.55)	(-0.41)	(-0.47)
Controls	225	365	415	418	448	426	388	300	131	57
Treated units	349	394	375	289	324	296	253	144	69	57
Covariates	No	No	No	No	No	No	No	No	No	No
Kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Order Loc. Poly.	1	1	1	1	1	1	1	1	1	1
Order Bias	2	2	2	2	2	2	2	2	2	2
BW Loc. Poly.	96.07	104.1	113.2	120.1	180.7	198.9	247.7	308.1	285.8	252.1
BW Bias	133.1	149.0	172.7	206.4	278.0	318.1	362.0	446.8	462.5	439.8

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial and postal surveys. IGN data, [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: RD estimates on different population thresholds are displayed.

Instrumental variable estimations

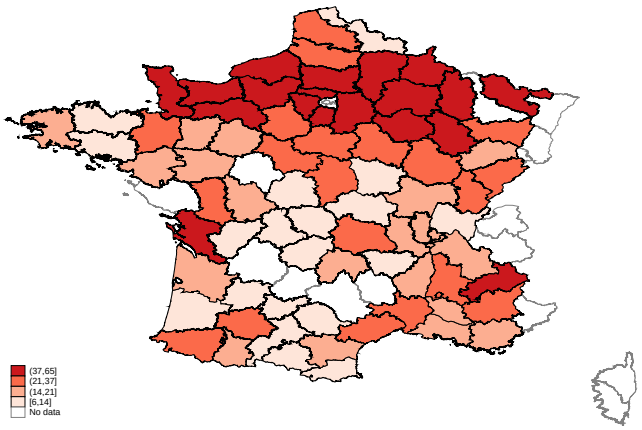


Figure B6: Literacy of men, 1686-1690

Source: *Statistique générale de la France*

Notes: Literacy is measure as the proportion of men who could sign their marriage contract.

Table A6: Printing press and literacy in 1686-1690 at the department level

	(1)	(2)	(3)	(4)	(5)	(6)
	Men	Women	Spouses	Men	Women	Spouses
Printing presses within 150kms	1.731**	0.975***	1.336***	–	–	–
	(2.538)	(2.926)	(2.696)			
Distance to printing press (Kms)	–	–	–	-0.052	-0.010	-0.027
				(-0.760)	(-0.281)	(-0.543)
Surface area	0.000	0.000	0.000	0.000	0.000	0.000
	(0.227)	(0.614)	(0.325)	(0.326)	(0.433)	(0.310)
Altitude	-0.005	-0.003	-0.004	0.000	-0.001	-0.000
	(-0.729)	(-0.950)	(-0.837)	(0.015)	(-0.163)	(-0.078)
Dep. with printing press	-0.226	-0.636	-0.382	-1.993	-0.139	-0.768
	(-0.063)	(-0.364)	(-0.147)	(-0.316)	(-0.044)	(-0.166)
Observations	75	75	75	75	75	75
R^2	0.088	0.113	0.098	0.013	0.006	0.008

Source: IGN data, *Statistique générale de la France*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: The unit of analysis is the department. Literacy is measured as the percentage of people who could sign their marriage contract. The administrative centre of departments, the *préfecture*, was taken as the point from which distances were measured for each unit of analysis.

Table A7: Printing press, postal taxes and industrial production

	Postal taxes		Industrial production	
	(1)	(2)	(3)	(4)
Printing presses within 100kms	0.978	–	-0.739	–
	(0.118)		(-0.237)	
Distance to printing press (Kms)	–	-0.558	–	-0.168
		(-1.485)		(-1.129)
Population	0.329***	0.331***	0.031***	0.031***
	(3.292)	(3.315)	(3.836)	(3.847)
Population dispersion	-1.694***	-1.594***	-0.359**	-0.326**
	(-4.440)	(-4.363)	(-2.498)	(-2.207)
Surface area	-0.474	-0.472*	-0.057**	-0.055*
	(-1.648)	(-1.689)	(-2.016)	(-1.856)
Altitude	0.046	0.043	0.010	0.008
	(0.787)	(0.755)	(0.551)	(0.435)
Latitude	2.577	3.947	2.849	3.163
	(0.455)	(0.705)	(0.811)	(0.957)
Dep. with printing press	3.045	-19.344	-15.050	-23.530*
	(0.163)	(-0.852)	(-1.171)	(-1.830)
Observations	6221	6221	6221	6221
R^2	0.194	0.195	0.021	0.022
Clusters	91	91	91	91

Source: Postal and industrial surveys, IGN data, [Motte et al., 2003], [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year.

Table A8: OLS and IV estimations - Schooling years, enrolment and municipal resources

	Log of municipal resources, francs per capita - 1881							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.050***	0.245***	–	–	–	–	–	–
	(4.636)	(3.353)						
Log of enrolment	–	–	0.125***	0.671***	0.140***	0.665***	0.282***	0.858***
			(4.461)	(2.847)	(4.982)	(3.290)	(7.809)	(3.556)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Distance to printing press		-0.020***		-0.008***		-0.007***		-0.004***
		(-18.17)		(-12.58)		(-14.67)		(-6.18)
Observations	5479	5479	4409	4409	5176	5176	1126	1126
R^2	0.581	0.221	0.581	0.245	0.590	0.240	0.564	0.249
$F-stat$		17.964		11.415		14.181		5.623
Regression-based p-value		0.000		0.001		0.000		0.013
Clusters	85	85	83	83	85	85	81	81

t statistics in parentheses

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

Table A9: OLS and IV estimations - Schooling years, enrolment and municipal resources

	Log of municipal resources, francs per capita - 1911							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.042***	0.098**	–	–	–	–	–	–
	(5.162)	(2.454)						
Log of enrolment	–	–	0.104***	0.234**	0.115***	0.253***	0.226***	0.395***
			(5.165)	(2.519)	(5.777)	(2.810)	(7.787)	(3.108)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Printing presses within 100kms		0.626***		0.228***		0.231***		0.178***
		(18.28)		(14.60)		(17.19)		(9.74)
Observations	5472	5472	4405	4405	5170	5170	1123	1123
R^2	0.589	0.243	0.584	0.264	0.600	0.262	0.569	0.282
$F-stat$		21.249		12.052		16.108		29.769
Regression-based p-value		0.108		0.131		0.099		0.184
Clusters	85	85	83	83	85	85	81	81

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

Table A10: OLS and IV estimations - Schooling years, enrolment and municipal resources. Robustness check on outliers

	Log of municipal resources, francs per capita - 1881							
	Municipalities more than 13kms and less than 133kms away from the printing press							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.046***	0.126**	–	–	–	–	–	–
	(4.241)	(2.251)						
Log of enrolment	–	–	0.118***	0.296**	0.131***	0.313**	0.281***	0.562***
			(4.219)	(2.214)	(4.596)	(2.450)	(7.592)	(3.673)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Printing presses within 100kms		0.596***		0.216***		0.222***		0.192***
		(16.19)		(13.37)		(15.74)		(9.61)
Observations	5076	5076	4165	4165	4839	4839	959	959
R^2	0.579	0.239	0.590	0.266	0.593	0.263	0.550	0.276
$F-stat$		16.795		10.397		13.869		34.524
Regression-based p-value		0.095		0.140		0.112		0.041
Clusters	81	81	78	78	81	81	77	77

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres. Only municipalities more than 13 kilometres and less than 133 kilometres away from printing presses are taken into account. This amounts to excluding the top 5% and the bottom 5% in terms of distance to the printing press.

Table A11: OLS and IV estimations - Schooling years, enrolment and municipal resources. Robustness check on municipalities close to the printing press

	Log of municipal resources, francs per capita - 1881							
	Municipalities more than 35kms away from the printing press							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.057***	0.178***	–	–	–	–	–	–
	(5.020)	(2.697)						
Log of enrolment	–	–	0.140***	0.387***	0.155***	0.403***	0.289***	0.651***
			(4.856)	(2.742)	(5.283)	(2.986)	(7.334)	(3.899)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Printing presses within 100kms		0.629***		0.252***		0.255***		0.182***
		(15.26)		(13.55)		(16.08)		(8.20)
Observations	4295	4295	3405	3405	4030	4030	925	925
R^2	0.576	0.293	0.584	0.341	0.589	0.332	0.576	0.305
$F-stat$		16.552		14.912		18.387		21.315
Regression-based p-value		0.011		0.022		0.017		0.009
Clusters	81	81	79	79	81	81	72	72

t statistics in parentheses

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres. Only municipalities more than 35 kilometres away from printing presses are taken into account. This amounts to excluding the bottom 25% in terms of distance to the printing press.

Table A12: IV estimations - Schooling years, enrolment and municipal resources. Robustness check: alternative radii for the number of printing presses

	Log of municipal resources, francs per capita - 1881							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.147***	0.161***	–	–	–	–	–	–
	(2.797)	(2.978)						
Log of enrolment	–	–	0.372***	0.416**	0.384***	0.466***	0.481***	0.786***
			(2.748)	(2.389)	(2.964)	(2.961)	(3.035)	(4.955)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Printing presses within 75kms	0.843***		0.319***		0.316***		0.238***	
	(17.15)		(14.65)		(16.45)		(8.40)	
Printing presses within 150kms		0.461***		0.153***		0.158***		0.133***
		(22.45)		(15.21)		(18.91)		(11.53)
Observations	5479	5479	4409	4409	5176	5176	1126	1126
R^2	0.237	0.274	0.264	0.273	0.258	0.277	0.276	0.329
$F-stat$	18.315	23.902	12.679	10.564	15.136	15.604	21.090	34.359
Regression-based p-value	0.019	0.020	0.017	0.053	0.016	0.015	0.155	0.000
Clusters	85	85	83	83	85	85	81	81

t statistics in parentheses

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

Table A13: OLS and IV estimations - Schooling years and municipal resources. Robustness check on different population intervals

	Log of municipal resources, francs per capita - 1881								
Population intervals	Bottom 75%			Bottom 90%			Top 25%		
	OLS	IV	IV	OLS	IV	IV	OLS	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Schooling Years	0.049***	0.163***	0.251***	0.054***	0.158***	0.235***	0.082***	0.192***	0.265***
	(4.045)	(2.663)	(2.937)	(4.726)	(3.010)	(3.471)	(6.815)	(3.830)	(3.373)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:					**Schooling years**				
Printing presses within 100kms		0.557***			0.609***			0.616***	
		(15.05)			(18.71)			(11.32)	
Distance to printing press			-0.021***			-0.022***			-0.012***
			(-14.92)			(-18.16)			(-7.22)
Observations	4373	4373	4373	5126	5126	5126	1106	1106	1106
R^2	0.582	0.264	0.252	0.592	0.258	0.241	0.555	0.278	0.228
$F-stat$		12.280	13.658		18.638	18.742		33.225	7.322
Regression-based p-value		0.022	0.001		0.017	0.000		0.009	0.016
Clusters	83	83	83	85	85	85	81	81	81

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.

Table A14: GMM estimations - Schooling years, enrolment and municipal resources. Robustness check accounting for spatial autocorrelation. Bottom 75% of the population

	Dependent variable: Log of municipal resources, francs per capita - 1881							
Spatial standard errors:	25 km radius		50 km radius		75 km radius		100 km radius	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.163***		0.163***		0.163**		0.163**	
	(0.016)		(0.016)		(0.016)		(0.016)	
	[0.041]		[0.059]		[0.067]		[0.071]	
Log of enrolment		0.396***		0.396***		0.396***		0.396**
		(0.038)		(0.038)		(0.038)		(0.038)
		[0.093]		[0.132]		[0.152]		[0.162]
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4373	4362	4373	4362	4373	4362	4373	4362

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: The spatial GMM estimations rely on the number of printing presses within 100 kilometres as an instrument. Conley standard errors corrected for spatial autocorrelation [Conley, 1999] are reported in square brackets. Regular standard errors are reported in brackets. The spatial correlation in error terms is considered as linearly declining along a 25, 50, 75 or 100 radius from each observation.

Table A15: GMM estimations - Schooling years, enrolment and municipal resources. Robustness check accounting for spatial autocorrelation. Top 25% of the population

	Dependent variable: Log of municipal resources, francs per capita - 1881							
Spatial standard errors:	25 km radius		50 km radius		75 km radius		100 km radius	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	0.191***		0.191***		0.191***		0.191***	
	(0.026)		(0.026)		(0.026)		(0.026)	
	[0.035]		[0.045]		[0.050]		[0.053]	
Log of enrolment		0.659***		0.659***		0.659***		0.659***
		(0.090)		(0.090)		(0.090)		(0.090)
		[0.118]		[0.152]		[0.171]		[0.183]
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1104	1104	1104	1104	1104	1104	1104	1104

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].

Notes: The spatial GMM estimations rely on the number of printing presses within 100 kilometres as an instrument. Conley standard errors corrected for spatial autocorrelation [Conley, 1999] are reported in square brackets. Regular standard errors are reported in brackets. The spatial correlation in error terms is considered as linearly declining along a 25, 50, 75 or 100 radius from each observation.

Table A16: Public subsidies and municipal resources, francs per capita

	1881					1911				
	No subsidy		Subsidy			No subsidy		Subsidy		
	N	Mean	N	Mean	p-value	N	Mean	N	Mean	p-value
Fixed salary	1570	5.83	2670	10.01	0.000	1575	11.22	2670	16.91	0.000
High salary	905	7.95	1815	11.28	0.000	906	13.82	1812	18.77	0.000
Accommodation, classroom	1999	7.18	2241	9.61	0.000	2001	13.29	2244	16.14	0.000
Other occupation	1810	6.54	2276	10.03	0.000	1814	11.71	2275	17.26	0.000
2nd degree certificate	2648	7.80	1592	9.58	0.000	2650	14.04	1595	16.06	0.000

Source: Guizot survey and *La Situation Financière des Communes*.

Notes: There are 1570 municipalities with a primary school in the data which didn't provide a fixed salary to the teacher. The average level of resources per capita of these municipalities was around 5.83 francs in 1881. The respective figures for municipalities paying teachers on a fixed basis are 2670 and 10.01 francs per capita. The difference between the two is significant at a one-percent level. The *High salary*, variable is equal to one if the municipality was paying the teacher more than 200 francs per year, which is the median fixed salary level.

Table A17: Covariates balance test on matched sample

	1881					1911				
	Sample mean					Sample mean				
	Treated	Control	Percent bias	Percent bias reduction	t-statistic (p-value)	Treated	Control	Percent bias	Percent bias reduction	t-statistic (p-value)
Log of enrolment	2.16	2.1461	1.8	97.4	0.60 (0.548)	2.1593	2.1408	2.4	96.5	0.80 (0.424)
Schooling years	5.6299	5.6033	1.4	97.5	0.46 (0.649)	5.627	5.6049	1.2	97.9	0.38 (0.706)
Population - 1833	789.12	821.33	-4.1	71.9	-1.36 (0.174)	788.43	824.5	-4.6	68.6	-1.52 (0.128)
Population dispersion	35.998	35.471	1.6	96.6	0.50 (0.617)	36.025	35.658	1.1	97.6	0.35 (0.728)
Surface area	147.54	145.01	2.0	91.8	0.68 (0.499)	147.49	144.66	2.2	90.9	0.75 (0.451)
Printing presses (100kms)	2.3668	2.4041	-2.7	72.6	-0.89 (0.374)	2.3697	2.3955	-1.9	81.6	-0.61 (0.541)
Distance to post office	6.555	6.7669	-4.7	55.3	-1.50 (0.134)	6.5621	6.7631	-4.5	56.9	-1.42 (0.155)
Postal taxes	154.03	169.92	-2.7	67.3	-1.63 (0.104)	153.99	170.17	-2.8	66.8	-1.66 (0.098)
Industrial taxes	51.244	46.989	1.7	82.9	0.53 (0.599)	51.468	54.383	-1.1	87.9	-0.35 (0.726)
Distance to economic centers	118.85	116.42	4.4	68.3	1.41 (0.160)	118.88	117.25	3.0	78.8	0.94 (0.345)

Source: Guizot, industrial, postal surveys, IGN data. [Motte et al., 2003] and *La Situation Financière des Communes*.

Notes: When using the matching technique for the year 1881, the average log of enrolment in the treated group is around 2.16, around 2.1461 in the control group. The bias associated corresponds to the difference between the expected enrolment in the treated group and the expected enrolment in the control matched group [Rosenbaum and Rubin, 1985]. It is reduced of 97.4% compared to the difference between the expected enrolment in the treated group and the expected enrolment in the control group without matching. The t-test p-value indicates that the difference in enrolment between matched treated and control groups is not significant.

Table A18: Matching estimations - Public subsidies and log of municipal resources, francs per capita

	Nearest-neighbor, common support, caliper of 0.2 std. of propensity score							
	1881				1911			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fixed salary	0.185***	–	–	–	0.135***	–	–	–
	(7.497)				(7.070)			
High salary	–	0.127***	–	–	–	0.097***	–	–
		(4.434)				(4.375)		
Accommodation, classroom	–	–	0.023	–	–	–	0.048**	–
			(0.814)				(2.282)	
Other occupation	–	–	–	0.097***	–	–	–	0.077***
				(3.617)				(3.720)
Observations	3960	2698	3262	3596	3960	2694	3260	3594

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys, IGN data. [Motte et al., 2003] and *La Situation Financière des Communes*.
Notes: All variables are dummy ones, indicating if the municipality at stake was subsidising primary education. The *High salary*, variable is equal to one if the municipality was paying the teacher more than 200 francs per year, which is the median fixed salary level.

Table A19: OLS and IV estimations - Schooling years, enrolment and growth of municipal resources

	Growth municipal resources, francs per capita - 1881-1911							
Population intervals			Bottom 75%		Bottom 90%		Top 25%	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Schooling Years	-2.129*	-15.356**	–	–	–	–	–	–
	(-1.813)	(-2.237)						
Log of enrolment	–	–	-5.189*	-39.715**	-6.046**	-39.711**	-14.381***	-61.319**
			(-1.886)	(-2.071)	(-2.074)	(-2.173)	(-2.749)	(-2.573)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage, dependent variable is:	**Schooling years**				**Enrolment rate**			
Printing presses within 100kms		0.510***		0.191***		0.195***		0.168***
		(13.61)		(11.41)		(13.16)		(7.76)
Observations	5409	5409	4358	4358	5111	5111	1107	1107
R^2	0.158	0.241	0.171	0.262	0.159	0.260	0.125	0.285
$F-stat$		21.099		12.046		16.145		30.353
Regression-based p-value		0.017		0.026		0.025		0.018
Clusters	85	85	83	83	85	85	81	81

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Guizot, industrial, postal surveys and IGN data. [Motte et al., 2003], *La Situation Financière des Communes*, [ISTC, 1998] and [Febvre and Martin, 1999].
Notes: Population dispersion is measured in percentage, the surface area in tens of hectares and altitude in meters. Postal taxes are in francs, the industrial production in thousands of francs per year. All distances are reported in kilometres.