N m'a faamu[*]

Boosting Learning Through Bilingual Education: Evidence from Mali

Mathilde Col[†]

Abstract

Bilingual education is increasingly recognized as a tool to address learning deficits in linguistically diverse contexts such as sub-Saharan countries. In this study, I analyze the long-term impacts of Mali's 1999 bilingual education reform, which introduced local languages alongside French in primary schools. Using a Difference-in-Differences approach with detailed school-level data, I find that exposure to the reform improved literacy in both French and local languages and increased school attendance, particularly for women. Robustness tests using modern econometric techniques relaxing the assumption of homogeneous treatment effect confirm these results. However, its effectiveness depends on sufficient educational resources, such as low pupil-to-school ratios. These findings highlight the potential of mother tongue-based instruction to enhance learning and promote equity when paired with adequate school inputs.

[*]"I don't understand" in Bamanakan

[†]PhD student. University of Bordeaux and Paris School of Economics. https://mathildecol.github.io/

1 Introduction

Learning levels are critical in Sub-Saharan Africa (SSA) (UNESCO, 2013). Despite a large increase in school enrollment over the past decades, literacy levels have not followed the same trends (World Bank, 2024). Almost 60% of the students assessed during the 2018 PASEC wave did not have sufficient skills in mathematics and reading (PASEC, 2020)[1]. Among other consequences, low literacy levels negatively affect formal employment and wages in adulthood (Baldini Rocha and Ponczek, 2011). Many constraints prevent gains in years of schooling to yield higher human capital accumulation. Recent literature has focused on supply-side constraints, such as the lack of education endowments or the insufficient knowledge and pedagogical skills of teachers to explain this lack of transmission (e.g.,Bold et al., 2017; Glewwe and Muralidharan, 2016). While the language of instruction is an essential feature of the curriculum, fewer studies have investigated the lack of direct transmission from schooling to human capital through the role of foreign language usage as the language of instruction.

When the linguistic distance between a child's mother tongue and the foreign language used as the medium of instruction is significant, as is often the case in Africa, effective learning is hindered because a foundational understanding in a familiar language is essential for cognitive development (UNESCO, 2016). In 2022, eighteen countries in the region still used the colonial language as the official medium of instruction in the first grades (Col, 2024). The other countries rely almost all on a bilingual education system, with the use of a local and vehicular language as the main medium of instruction for the first grades, transitioning slowly to the colonial language use only at the end of the primary cycle. The use of colonial official languages in administration is empirically associated with poor development outcomes (Laitin and Ramachandran, 2016, 2022).

While a large literature in linguistics has highlighted the benefits of learning in the mother tongue (Rolstad, Mahoney, and Glass, 2005; Sakaryalı, Bal, and Yıldırım, 2024 for meta-analyses), only a few papers in economics estimated its causal effects on learning and schooling (e.g., Cummins, 2000; Laitin, Ramachandran, and Walter, 2019; Ramachandran,

[1] 14 countries were part of the last PASEC (*Programme d'Analyse des Systèmes Educatifs de la CONFEMEN*) evaluation, making it one of the largest international tests in SSA

2017). First, students who learn in their mother tongue have better learning outcomes (Benson, 2002; Cummins, 2000). In a recent randomized controlled study in Cameroon, Laitin, Ramachandran, and Walter (2019) show that grades 1 and 3 students taught in the local language had better test scores in math and English, amounting to more than one standard deviation. In addition, it also reduces the gender gap in learning as girls seem to benefit the most from introducing local languages in education (Benson, 2005; Benson and Wong, 2019). These results provide evidence that teaching in the local language enhances students' learning outcomes. Second, mother tongue instruction increases schooling attendance. For instance, the 1994 Ethiopian reform introducing Oromo in primary schools increases the probability of completing primary schooling by five percentage points, roughly half a year of schooling (Ramachandran, 2017; Seid, 2016). Finally, in the long run, human capital accumulation gains from mother-tongue education seem to translate into wage increases. For instance, Eriksson (2014) finds that the South Africa 1957 Bantu Act, which increases exposure to mother tongue instruction, results in a 1.5–4% increase in wages.

These findings rely on highly controlled and small-scale experiments or relying on weak identification strategies, limiting their external validity. Piper, Zuilkowski, and Ong'ele (2016) highlight these difficulties in implementing the scale-up of a mother-tongue instruction program in Kenya. They show that many teachers were not speakers of the languages and needed additional training, some communities resisted mother-tongue instruction, and some areas were not language homogeneous. Moreover, this literature focuses mainly on short-term effects, ignoring the potential long-term effects of such policies. For instance, while students in these tracks retain more when tested at the end of the school year, we do not know whether it translates into better literacy outcomes in adulthood in both local and official languages.

This paper provides some of the first empirical evidence of the long-term effect of introducing bilingual language on human capital accumulation. I exploit a nationwide linguistic education reform in Mali in 1999 to assess such effects. I leverage granular data at the school level on the implementation of this reform to estimate precise returns to bilingual education. These returns range from learning skills in the colonial (in this case, French) and the local language to schooling outcomes, such as school attendance and rate

of completion of the primary cycle.

Mali is one of the sub-Saharan countries in where school enrollment is still a policy issue. Learning levels are also extremely low with only 30% of the adult population literate in 2020 (World Bank, 2024). Until 1999, French was the only language of instruction in primary schools, despite a high linguistic diversity with 63 living languages, including 57 stable & institutional (Lewis, Simons, and Fennig, 2016). In 1999, the Ministry of Education enforced a nationwide reform of the primary education system with a strong focus on building schools and introducing 11 national languages as media of instruction. The school building component was not as successful as expected: from 2002 to 2018, the net enrollment rate in primary education (i.e., the percentage of children of school age enrolled in primary schools) went from 50% to less than 60% (World Bank, 2024). However, detailed data from official reports indicate that the language component was well implemented throughout the country.

Using school-level information on the languages used at school, I accurately estimate the bilingual education (BE) supply at the commune level as the share of schools offering bilingual education over the total number of schools. Because the BE supply is highly correlated with the district location, I take the median share of bilingual schools at the district level and use this threshold to define low and high-intensity BE exposure at the commune level[2]. I use a Difference-in-Difference (DiD) strategy comparing birth cohorts in high-intensity BE provision to birth cohorts in low-intensity BE provision before and after the implementation of the reform. I rely on the 2018 LSMS survey to have an objective, accurate, and tested measure of human capital accumulation. Individuals more exposed to the linguistic reform are 4 percentage points (pp) more likely to be literate in French, and 5pp in the local language once they are adults. School attendance also increases by 5pp. This result hides heterogeneity. Indeed, women benefit the most from this reform and experience higher returns to bilingual education for all educational outcomes. However, offering bilingual education alone is not enough but seems highly effective when paired with sufficient educational endowments (e.g., low pupils-per-school ratio). Using the last advances in the DiD literature, I find that results are robust to alternative speci-

[2]Commune is the lowest administrative unit. It is located within a district (*cercle*), and thie higest unit is the region.

fications considering the share of bilingual schools as a continuous variable or considering a difference in the timing of the treatment.

This paper contributes to three strands of the literature. First, I provide new empirical evidence of returns to schooling for specific type of schooling: bilingual education. Previous works show large returns to primary education in sub-Saharan Africa, especially for women (Duflo, 2001; Montenegro and Patrinos, 2014; Psacharopoulos and Patrinos, 2004). However, little is known about the returns of bilingual education. This paper provides the first step of the analysis, looking at schooling gains in adulthood. It suggests future avenues for research into looking at wage gains or losses in the long run. Moreover, rather than looking only at a stock of years of education, I add a quality dimension to the analysis of returns to schooling, by focusing on literacy in different languages.

Second, I contribute to the recent and growing literature evaluating at-scale policies. Implementation is key when understanding the differential impacts of education programs (Angrist and Meager, 2023). However, it is widely acknowledged that scaling up a successful intervention is not straightforward. Evidence on bilingual education interventions that translated into countrywide policies shows mixed results because of a difficult implementation (Piper, Zuilkowski, and Ong'ele, 2016). I add to this strand of the literature by showing evidence from a successful scaled-up policy. Part of this success can be explained in the importance of piloting that was put into the preparation of this reform (Ba, 2009).

Finally, I bring additional evidence on a beneficial education intervention and input: the bilingual curriculum. A recent meta-analysis on education inputs finds that mother tongue instruction shows promising results in controlled experimental settings (Evans and Mendez Acosta, 2021). The present paper adds to these early findings and highlights their complementarity with broader reform. This additional school input should be considered in complementarity with other education endowments (Glewwe and Muralidharan, 2016). I show that a not-too-high ratio of pupils per school is needed for bilingual education to be effective. Further research is required in order to document other complementarity that might explain the failure or success of bilingual education at scale (Col, 2024).

This paper is organized as follows. In Section 2, I document the 1999 linguistic reform and what preceded it. Section 4 presents the theory of change underlying. Section 3 details the data used for the empirical analysis. I explain the main empirical strategy in

Section 5 and show the results in Section 6. Finally, I address the main concerns and run robustness checks in Section 7.

2 Context

2.1 Historical background in bilingual education

Despite Mali's official language of instruction being French at all education levels until the early 2000s, there is a long-lasting history of bilingual education in Mali. Two years after independence, in 1960, experiments started using local languages to expand schooling for adults who did not attend school under colonial rule (UNESCO, 1963). Following positive results from these experiments, it expanded to primary education at the onset of the 1980s (Ba, 2009; Diarra, 2020).

First generation experimental schools. In 1979, 4 schools opened bilingual education classes in Bamanankan, the main vehicular language in Mali (Calvet, 1993; Traoré, 2001). Teachers used the local language only in the first four years of primary education. Positive evaluations of the bilingual program at the beginning of the experiment led to its rapid expansion. A few years later, almost 100 schools operated in the four main languages: Bamanankan, Songhay, Tamasheq, and Fulfulde (Hutchison, Diarra, and Poth, 1990; Skattum, 2010). Lack of monitoring, teacher training, and sufficient budget led to the end of the first experimentation at the beginning of the 1990s (Skattum, 2010).

The *Pédagogie Convergente*. This new experiment, developed and piloted by a Belgian linguistics center (the CIAVER[3]), started in 1987 with two classes in Segou in Bamanankan. After a positive evaluation of the pilot, it rapidly expanded in 1994 to other languages and counted a bit more than 100 schools in 1997 (Traoré, 2001). Contrary to the first experimental schools, the 6 years of primary education were entirely taught in the local language, with a progressive introduction to French once students fully mastered the mother tongue.

Qualitative and quantitative evaluations conducted during the experiment provided

[3]Centre International Audiovisuel d'Études et de Recherches

mixed evidence about its results (Skattum, 2010; Traoré, 2001). Maurer (2007) also reported implementation issues that hindered the program's scale-up.

2.2 The 1999 bilingual education policy

Scaling up. In 1999, the Ministry of Education took over the bilingual education experiment. It scaled it at a national level as an essential component of the PRODEC, a massive countrywide educational reform aiming at expanding primary schooling coverage under the name of *Curriculum bilingue*[4] (Loua, 2017). The main objective of this reform was to build schools massively, starting from where it was most needed to the other places (African Development Bank Group, 2003). Consequently, school supply increased rapidly, from 2,600 schools in 1998 to almost 10,000 in 2008. The linguistic component of the PRODEC reform was built on past experiments detailed previously. In 2002, we counted 2,110 bilingual classes and 666 schools with at least one bilingual track throughout the country in 11 languages (Bamanankan, Songhay, Tamasheq, Soninke, Dogon, Fulfude, Bomu, Syenara, Mamara, Bozo, and Khassonke) and 121,734 enrolled students.

After a massive expansion in the early 2000s, the number of bilingual schools peaked at 2,530 in 2005, representing around one-third of the total number of schools. Since then, due to a lack of funding and political will, this number has stagnated and even decreased. Nowadays, bilingual education has not yet spread throughout the country and has leveled out at around 25% of the schools due to a lack of budget and political engagement.

Organization. Qualitative evidence points to a bottom-to-top process. To open a bilingual education track in a school, local leaders had to ask the local committee in charge of scaling up bilingual education. In collaboration with the community, this committee would choose the main language to be spoken in the bilingual class by the teachers and students as the language of instruction. Schools would receive textbooks in the selected language, and teachers would follow a short additional training course to deal with this new curriculum. Monitoring data collected in 2011 show that the vast majority of teachers received this training (Diarra, 2013). However, little is known about the quality and extent of this training because Malian bilingual education expansion followed a very decentralized

[4]Bilingual curriculum, in English

process (Ba, 2009).

Implementation. Angrist and Meager (2023) recently showed that implementation is the key determinant in explaining the heterogeneity effects of education programs. Few studies thoroughly documented the implementation in practice of the countrywide bilingual policy: while the first years were promising, a field study conducted by the Ministry of Education in 2011 showed that almost one-quarter of schools that opened at least one bilingual education track had to close it since. One motive slightly documented in the literature is the lack of demand from parents. Low expected labor outcomes (Ramachandran and Rauh, 2022) or misbeliefs about what bilingual education is (Chimbutane and Reinikka, 2023) are key drivers of this low take-up in similar contexts. In Mali, Diarra (2018) provided qualitative evidence of misinformation about the *Curriculum bilingue*, pushing parents to withdraw their children from bilingual tracks for French-only ones after 2010.

Bilingual education in practice The *Curriculum bilingue* was initially thought of by policymakers as a progressive introduction to French for Malian students. Instead of learning French in French directly in grade 1, students are expected to spend the first years of primary education learning the basics of writing and reading in the local vehicular language before transitioning to French using what they learned previously:

1. During the first two years, the curriculum is mainly in the local language chosen;
2. The next two years, French is gradually introduced. At the end of grade 4, half of the curriculum is taught in French and the other half in the local language;
3. During the last two years, French becomes the dominant language.

French remains officially the only language of instruction in the secondary cycle of primary education. The same rule applies to secondary and tertiary education cycles.

3 Data

3.1 Roll-out of the bilingual education program

Sources. To document the expansion of bilingual education in Mali, I use original data from several reports published by the Bilingual Education Department within the Ministry of Education between 2002 and 2011[5]. I also use data on the first experiment, the *Pédagogie convergente*, from a PhD thesis in linguistics (Diarra, 2020).

Coverage. From the different sources detailed previously, I can document four periods: the first experiment from 1994 to 1997, then 2002, 2005, and 2011. The program did not cover all regions and languages during the first years and expanded progressively. From 1994 to 2005, I have only aggregated data at the district level. Table A.1 details which geographical level and information available at a given year in the dataset I compiled.

Figure A.1 shows the evolution of the number of bilingual schools between these periods: before the 2000s, the bilingual education supply was close to zero. After the official introduction of bilingual education in the curriculum in 2000, this number progressively increased to reach 25% of all primary schools. Hence, I consider the birth cohort that entered primary education in 2000 as the first treated cohort in the empirical analysis.

Listing of bilingual schools. I rely on another source to overcome the lack of precision with respect to the exposure to bilingual education, which is so far at the district level. In 2011, linguistics experts did a census on behalf of the Ministry of Education of bilingual schools that were declared officially as "opened" at the October 2011 school start. Using this report, I assemble a dataset indicating the status for every bilingual school: (i) whether the bilingual curriculum is still used and if yes, whether it is used for all grades or only the first ones; (ii) or was abandoned for the French-only curriculum. Because of the ongoing civil war at the time of the data collection, they could only do the census in the following regions: Bamako, Kayes, Koulikoro, Segou, and Sikasso. Even if these regions account for only half of the Malian territory, 78% of the population live in these regions, reducing the external validity threat of my empirical analysis (INSTAT-Mali, 2017).

[5]I deeply thank Youssouf Haidara for sharing his time and archives with me.

3.2 School supply

Using the population census data from 1998 and 2009, I rely on a panel dataset on school supply at the village level[6]. I use this information to create a meaningful indicator of exposure to bilingual education at the commune level: the ratio between the number of bilingual schools and the total number of schools.

Indeed, one of the main objectives of the PRODEC was to build more school buildings to match the school supply with the increasing demand. Figure A.1 provides an overview of the evolution over time of the school supply: the number of schools improved rapidly during the 2000s. While one may argue that the increase in the provision of bilingual education is paired with the building of new schools, threatening the validity of my empirical strategy, I address this potential caveat in 7.3.

3.3 Human capital

Measurement of literacy. I use literacy as a proxy for education quality. Literacy is a widespread but poorly measured indicator in many surveys as it is often overestimated. Sandefur (2017) provides evidence using Demographic and Health Surveys in developing countries about the under-reporting of illiteracy. He shows that after a certain point in education years (usually after the primary cycle), the respondent is automatically considered as literate. However, the World Bank recently shows that in many sub-Saharan countries, through the Learning-Adjusted Years of Schooling (LAYS), more than finishing primary education is required to be literate when considering the quality of schooling (World Bank, 2024). Moreover, this indicator is still self-reported by respondents in many widely used surveys and censuses. Therefore, I use the 2018 Living Standards Measurement Study (LSMS) by the World Bank in 2018 to overcome this issue. Indeed, LSMS provides an objective measure of literacy by testing writing and reading skills in French, the local vehicular language, and another language.

Other outcomes. Besides literacy, I also use other educational outcomes: school attendance, completion of primary school, and the success rate at the end-of-the-first-primary

[6]I thank Flore Gubert for providing the panel dataset on the public infrastructures that were used in Chauvet et al. (2015)

cycle exam (i.e., all students in grade 6 are expected to pass it).[7] I do not consider the number of schooling years as the literature documented two opposite mechanisms (Benson, 2002): bilingual education affects positively the retainment rate of students, but it is also expected to decrease the repetition rate. Finally, as the youngest birth cohort in my sample turned 15 at the time fo the survey, looking at schooling years might be misleading as some of them have not finished their education path.

3.4 Linguistic diversity

A critical dimension of bilingual education that has not yet been discussed in this paper is the choice of language. As previously explained, the vehicular language that replaces French in schools is chosen among the 11 national languages. The entire community might not speak this vehicular language. Hence, even if the linguistic distance between the official language spoken at school and the mother tongue is reduced (Laitin and Ramachandran, 2022), community members speaking a minority language would still face the same understanding challenge.

I use the census data to compute the linguistic Herfindahl-Hirschman index using the number of speakers for every language at the commune level[8]. I also use the main language spoken in the community as a proxy for the language chosen to be the new language of instruction for the first grades.

3.5 Descriptive statistics

Table A.2 describes the main outcomes for the sample. It is a balanced sample, with half of the population considered a woman and half urban. We can notice that only 50% of the sample attended school, and the same fraction is literate in French (either writing or reading). Finally, only 1 out of 10 can write or read in the local language.

[7] In Mali, primary education starts at the age of 7 officially, for 6 years for the first primary cycle and 3 years for the second primary cycle. At the end of this first cycle, until 2010, students passed an exam called the *Certificat d'études primaires* (CEP) to pass to the second primary cycle

[8] To give a quick overview and explanation of the administrative system in Mali: a commune is composed of a set of villages; a district includes different communes; and a region is the upper level.

4 Theory of change

4.1 Primary hypotheses (PH)

I expect to observe empirically positive returns in the long run of bilingual education on quantity and quality aspects of human capital accumulation.

PH1: Bilingual education increases learning. On quality, the linguistics literature has shown in controlled and limited settings that learning in a familiar language increases literacy (Benson, 2002; Cummins, 2000; Ramachandran, 2017). Indeed, learning starts at the very beginning of primary instruction and is not postponed once the student has sufficient skills in the language of instruction. Second, bilingual education makes the connection between writing and speech easier (Hovens, 2002). Another advantage is linked to a particular linguistic feature of Sub-Saharan Africa: the spread of "mixed" languages, also known as *creoles* or *pidgins*, that take words or structures from different local and foreign languages (Calvet, 2010). Learning a second language through a familiar language reduces the risk of code-switching (i.e., using words from another language in the middle of a sentence), allowing the skill to transfer quickly from one language to the other (Cummins, 2000).

PH2: Bilingual education increases schooling. On the quantity aspect, bilingual education is expected to increase school attendance and, to some extent, the number of schooling years. Indeed, bilingual schools can attract students compared to monolingual ones when the language used at school is close to the home language (Ball et al., 2024). It also reduces the repetition rate and drop-out, leading to higher promotion rates (Patrinos and Velez, 2009).

4.2 Secondary hypotheses (SH)

SH1: Women benefit more from bilingual education. Empirical evidence in the linguistics literature shows that girls students have higher returns than boys in terms of schooling (Benson, 2002; Hovens, 2002). The primary mechanism behind these positive results is that girls are less exposed to the foreign language than boys in the home en-

vironment (O'Gara and Kendall, 1996). Hence, by bridging the gap between the school place and the home place, bilingual education yields higher human capital accumulation for girls (Benson, 2005).

SH2: Areas more linguistically diverse are less prone to positive returns to bilingual education. The more languages there are in one community, the less the fraction of the community speaking the same language. Therefore, in a very linguistically diverse area, the choice of the language to be spoken at school might not reflect the language spoken by the majority of students enrolled in the school. As a result, many students will not speak the new language of instruction, reducing the benefits of bilingual education.

SH3: Returns to bilingual education are higher in rural areas. It relates closely to SH1 and PH2 (see section 4.1). Indeed, rural areas are the most linguistically diverse while cities are places where all the country's languages are mixed and end up in mixed languages (Calvet, 2010). Therefore, French acts as a *lingua franca* in urban settings. Hence, because local languages are more used in rural areas as vehicular languages, I expect rural areas to benefit more from bilingual education than urban ones.

5 Empirical strategy

5.1 Identification strategy

Caveat of the naive comparison. A naive comparison of people attending monolingual (i.e., French-only) schools and those attending bilingual schools is likely to be biased. Indeed, people select themselves into education tracks (Agarwal and Somaini, 2020). Languages used for teaching are a motive for parents when selecting schooling offers. In Zambia, Ramachandran and Rauh (2022) found overwhelming support for keeping English as the medium of instruction. Therefore, a naive comparison would yield biased conclusions. I overcome this issue by using a quasi-experimental design leveraging the differential exposure to bilingual education at the commune level.

(Discrete) Treatment definition. I define continuous exposure to bilingual education (BE) at the commune c level as the following:

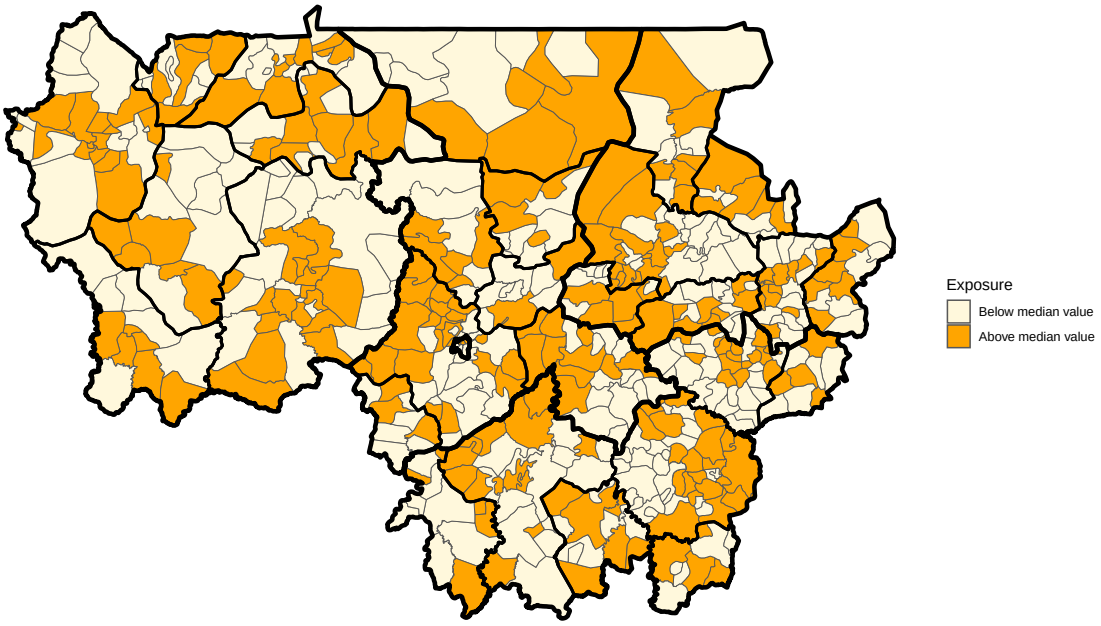
$$\text{Share of BE}_c = \frac{\text{Number of Bilingual Schools}_c}{\text{Number of Schools}_c}$$

I include in the numerator all schools officially declared as bilingual education schools in 2011, and in the denominator, the schools supply as given in the 2009 census. I consider the fraction of schools that dropped out of the bilingual curriculum in the section 7.4.

Figure A.2 shows at the commune level the fraction of bilingual schools among the total school supply. It follows a clear geographical pattern: some districts are uniformly more endowed in terms of bilingual schools compared to others. For example, the eastern Kayes region lags compared to other areas. The languages introduced can explain part of this pattern. For instance, the very first one introduced in school and the most widespread language in Mali is Bamanankan. The Sikasso region, where bilingual education seems very much present, also has many Bamanankan speakers.

Comparing communes between them based on the share of bilingual education would be comparing different regions or districts. The treatment effect would then be confounded with geographical differences. Instead, I use the median share of bilingual education within each district as a threshold and consider a commune with a share of bilingual schools below this median as a low-exposed area. Similarly, I consider a commune with a fraction of bilingual education higher than the district median as highly exposed. Figure 1 displays the geographical coverage of the treatment among the 167 communes in the sample. One important concern is that I compare low-exposed to high-exposed areas based on different median values of bilingual education exposure. I address this concern in Section 7.1 by relaxing the assumption of homogeneous treatment effects.

Continuous treatment. In alternative specifications I use recent econometric approaches to consider the full range of the bilingual education share among communes (Callaway, Goodman-Bacon, and Sant'Anna, 2024).



Wide black lines represent the regional borders, thin black lines represent the district borders, and gray lines represent the communal borders. The two colors indicate the treatment status at the commune level: whether the fraction of bilingual schools in each commune is higher or lower compared to the median share of bilingual education at the district level. This figure maps only the following regions that will be considered in the empirical analysis: Bamako, Kayes, Koulikoro, Segou, and Sikasso.

Figure 1: Map of the treatment status by commune

5.2 Empirical specification

Two Way Fixed-Effects. Figure A.1 provides evidence that before 2000, bilingual education was only offered to a few schools nationwide. I take advantage of this low implementation to implement a time threshold between non-exposed and exposed birth cohorts. Given that the official age to start primary school is seven, I consider the first birth cohort as treated people born in 1994 who should legally begin primary school in October 2001.

Combining this cohort-based exposure with the spatial relative intensity of exposure to bilingual education, I implement a difference-in-difference strategy to assess the impact of bilingual education on human capital accumulation. The estimated regression is the following:

$$Y_{i,y,c,d} = \alpha_{1,t}\mathbb{1}[\text{y} \geq 1994] + \alpha_{2,c}\mathbb{1}[\text{c} \in \text{BS}] + \beta_{y,c}\mathbb{1}[\text{y} \geq 1994] * \mathbb{1}[\text{c} \in \text{BS}] + \theta_d + u_{i,y,c,d} \quad (1)$$

With $Y_{i,y,c,d}$, the outcome for individual i, born in year y, living in the commune c, and the district d. $\alpha_{1,y}$ captures the effects of being born after 1994. $\alpha_{2,c}$ isolates the differences in the outcome that might exist between communes with a high share of bilingual schools compared to communes with a low share. The coefficient of interest is $\beta_{y,c}$, which captures the effect of being highly exposed to bilingual education (BE) compared to low exposure after 2000. I use district-fixed effects θ_d to overcome the issue highlighted in Figure A.2: I compare within each district communes with different exposures to BE (low vs. high), relative to the median share of BE supply in the district (respectively, below vs. above). I use the LSMS cluster provided in the survey to cluster standard errors, and I use household weights, also present in the survey. I include an age lower bound in the sample to study the long-term impact on human capital accumulation. As I consider only adults above 15, I take as an upper limit for the year of birth 2003 to be included in the sample (the survey took place in 2018).

Testing parallel trends. The key assumption underlying my identification strategy is that without the bilingual education reform, unexposed and exposed cohorts' outcomes would have followed the same trends. I provide evidence of parallel trends before the onset

of bilingual education. I estimate event studies for all outcomes specified earlier using the following regression:

$$Y_{i,y,c,d} = \sum_{t \in T} \alpha_{1,t} \mathbb{1}[t = y] + \alpha_{2,c} \mathbb{1}[\text{c} \in \text{BS}] + \sum_{t \in T} \beta_{t,c} \mathbb{1}[t = y] * \mathbb{1}[\text{c} \in \text{BS}] + \theta_d + u_{i,y,c,d} \quad (2)$$

The same definitions as in equation (1) apply. T represents the pre-treatment period covered in the study, i.e., 1986 to 1994. I allow the coefficient β to vary in the pre-treatment period according to the year of birth y.

Following the recent literature on the topic, I also implement a sensitivity analysis in 7.5 to test for violations in the pre-testing of parallel trends (Roth et al., 2023).

Staggered design. Leveraging data on the progressive roll-out in four points in time (1997, 2002, 2005 and 2011, as detailed in Table A.1), I use a staggered design as a complementary analysis in the section 7.2. I use recent econometric specifications to estimate the treatment effect on every group of districts according to their timing of first exposure to bilingual education (Borusyak, Jaravel, and Spiess, 2024). The roll-out data are only available at the district level from 1984 to 2011. Hence, even if the exact timing of the exposure gets more accurate with this design, I lose precision in the geographical areas targeted by bilingual instruction.

6 Results

6.1 Human capital accumulation

This subsection presents the average effects of exposure to bilingual education (BE) on human capital accumulation. I first test whether BE affects average learning and then schooling of treated cohorts.

Testing the parallel trends assumption. Figure 2 plots estimated coefficients along with 95% confidence intervals from the estimation of equation 2 explaining BE effects on learning outcomes in the local language. The figure shows that the linguistic reform has a significant, positive, and persistent impact on writing and reading in local languages.

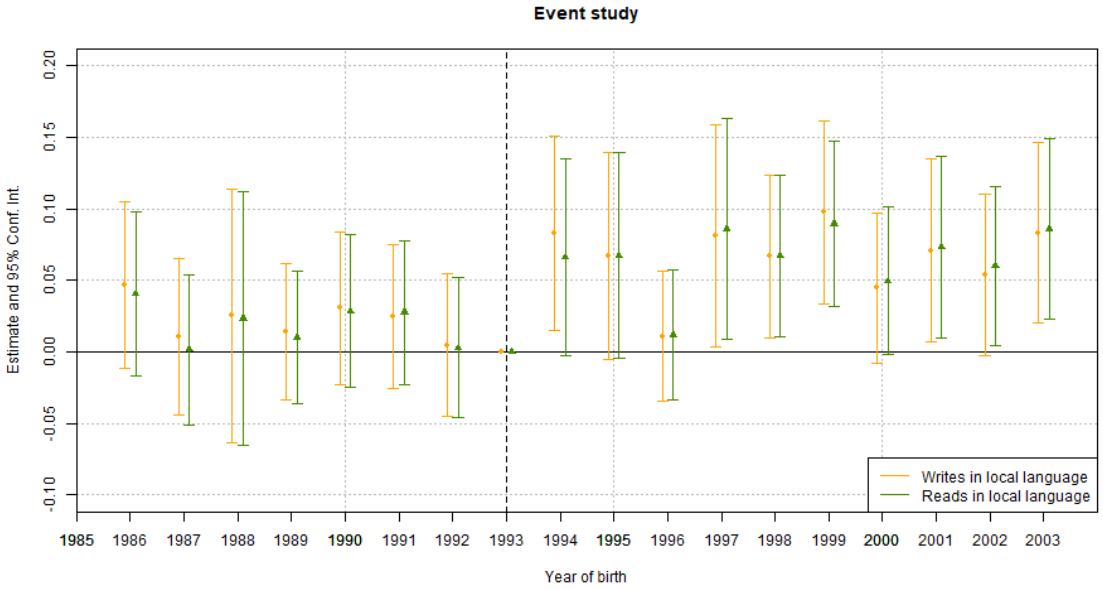
All the pre-trend coefficients are small and jointly non-different from zero. In addition, treatment coefficients are statistically significant at either the 5% level or 10% level. The event studies for the other education outcomes are shown in Figure A.3 and Figure A.4.

When looking at post-treatment period coefficients, I observe positive but inconsistent effects on learning in French and the local language for these birth cohorts. The small population each birth cohort represents at the commune level explains confidence interval variability. To ease the readability of the results, I will present the TWFE estimates (i.e., the average treatment effects) as the main results.

Learning. I use literacy in the local language and in French as the main measures of learning. Results are displayed in the Table 1. Columns (1) and (2) present the results on local languages, representing the first stage estimates. Indeed, as I expect the dominant language in the area to be selected as the language of instruction in bilingual schools, it provides useful information about the implementation of the bilingual curriculum in schools officially registered as bilingual. I observe a significant increase of 4 percentage points (pp) in the literacy skills (both writing and reading) associated with the local language for the treated cohorts. Given that only 12% of the sample is literate in the local language, being more exposed to bilingual education increases learning by more than 30%. It is aligned with the results of Ramachandran (2017) who found that introducing Oromo in Ethiopian primary schools increased literacy by 40%.

Then, results in columns (3) and (4) provide a similar pattern in literacy in French. On average, the literacy skills of treated cohorts increased by 5pp (meaning an increase of 10% of the literacy rate in the sample), both in writing and reading. However, these results are less significant and smaller in magnitude.

The richness of the LSMS data allows me to perform the same analysis on a convenient placebo outcome: literacy in another language that is not dominant in the surveyed area. The intuition is as follows: this outcome should not be affected at all by bilingual education, as this language is not likely to be used in bilingual schools in this area. Figure A.5 shows the event-study estimate and provides additional evidence supporting my identification strategy. I do not observe any change in writing and reading skills after introducing bilingual education.



Notes: Point estimates and 95% confidence intervals are derived from an event study regression over the 1985-2003 birth cohorts. In addition to time and commune fixed effects, I use district fixed effects to capture variation in the median of bilingual education share across districts. To obtain these estimates, I perform two distinct regressions: one with whether the individual knows how to write in the local language as the dependent variable (in orange), and one with whether the individual knows how to read in the local language as the dependent variable (in green). I cluster the standard errors at the LSMS cluster level, which corresponds roughly to the village level. Individuals born in 1993 are the last birth cohort to be taught entirely in French (i.e., not treated) represented by a black vertical dashed line.

Figure 2: Event study regression for literacy in the local language

Language tested	Local language		French	
Dependent Variables:	Writing	Reading	Writing	Reading
Model:	(1)	(2)	(3)	(4)
Variables				
Born after 1994	0.012	0.010	0.123***	0.122***
	(0.012)	(0.011)	(0.019)	(0.019)
High exposed commune	0.024	0.022	0.035	0.032
	(0.016)	(0.016)	(0.041)	(0.040)
Born after 1994 × High exposed commune	0.040**	0.043**	0.053*	0.054*
	(0.017)	(0.017)	(0.029)	(0.029)
Fixed-effects				
District FE	Yes	Yes	Yes	Yes
Fit statistics				
Mean of Y	0.123	0.118	0.506	0.502
Observations	7,727	7,716	7,727	7,726
R^2	0.04706	0.04588	0.13630	0.13341

Clustered (LSMS cluster) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: I use a linear regression specification to obtain the coefficient estimates. In additional to time and commune fixed-effects, I use district fixed-effects to capture the fact that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level, and use household weights given in the LSMS survey. The mean of the outcomes is a weighted mean, using the same weights. The dependent variables are in Column (1) Whether the individual knows how to write in the local language (0/1), Column (2) Whether the individual knows how to read in the local language (0/1), Column (3) Whether the individual knows how to write in French (0/1), and Column (4) Whether the individual knows how to read in French (0/1).

Table 1: TWFE results on learning outcomes

Schooling. Results are shown in Table A.3. I do not see any aggregated effect on the rate of completion or success at the end of the primary education cycle. The event studies in A.4 show positive and short run effects, it does affect only the first three treated cohorts. However, both the TWFE results and the event study point out that bilingual education attracts children in schools. I find an increase in schooling attendance of 10% for cohorts that got access to more bilingual schools. This result is aligned with the linguistics literature, which shows that a reduction in the linguistic distance between the home and the school environment incentivizes more parents to send their children to schools (Benson, 2004). In the economics literature, Seid (2016) found the same direction of the BE effect on school attendance in the Ethiopian context.

These results confirm the hypothesis made in Section 4: bilingual education boosts learning and schooling. In the next section, I will provide more information on the characteristics of the households that increased their demand for schooling when being exposed to more bilingual education.

6.2 Heterogeneity

I find empirical confirmation for the first two secondary hypotheses made in Section 4.2: (i) women have higher returns to schooling and (ii) less linguistic diversity is a condition for bilingual education to be efficient.

Sex. Heterogeneity results by sex are presented in Figure 3. Women drive the positive results, confirming previous findings about gender differences towards bilingual education (Benson, 2005). Women exposed to more bilingual education have better learning and schooling outcomes. They are 8pp more likely to master French, attend school, and 6pp more likely to succeed at the end-of-primary-school exam (CEP). Relative to the sample mean, it represents respectively an increase of 15% in the probability of being literate in French and attending school and 20% in the probability of passing the CEP. The only coefficient significantly different from zero only at the 10% confidence level is associated with the completion rate of primary education. Recent descriptive evidence in Sub-Saharan Africa showed that gender gaps in educational attainment worsened for most countries since the 1970s because boys benefited more from the large increase in school

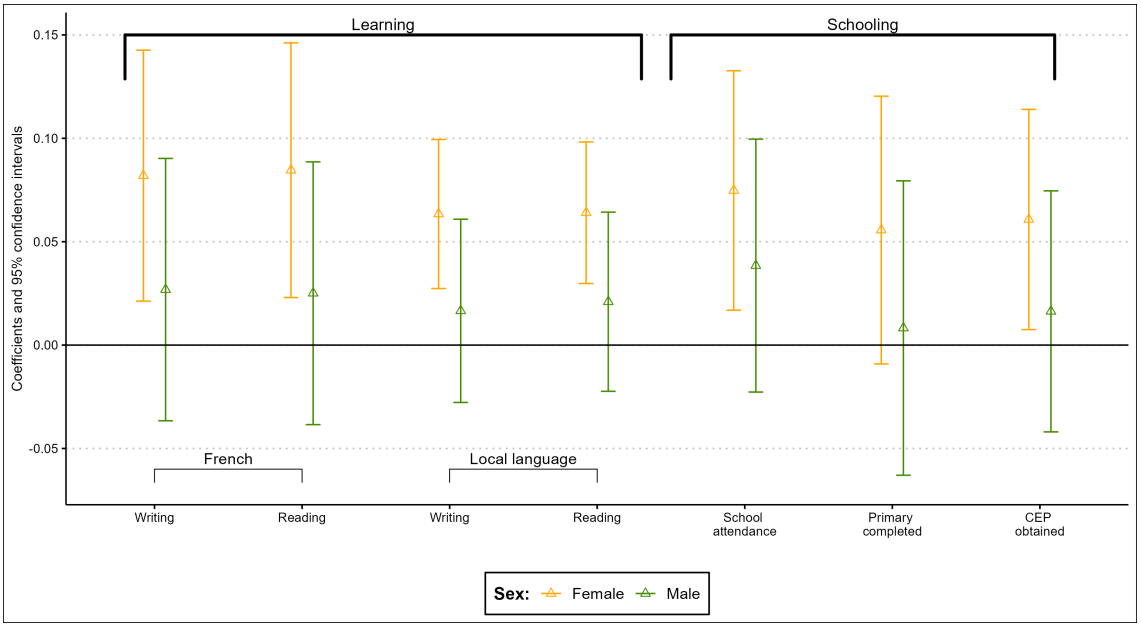
supply (Evans, Akmal, and Jakiela, 2021). Hence, expanding bilingual education appears to be an effective way to achieve the goal of reducing gender inequalities in education.

Linguistic diversity. I expect that areas with more linguistic diversity are also the ones that benefit less from the provision of bilingual education. To test this hypothesis, I use the information about the mother tongue of every individual given in the 2009 census and derive the linguistic Herfindhal-Hirschman index for every commune in my sample. I then divide the communes into quintiles of linguistic diversity. Empirical results in Figure A.6 do not present a straightforward picture. Even if learning and schooling outcomes are higher for the second quintile, there is no clear pattern. Hence, I cannot conclude that lower linguistic diversity within the community is beneficial for bilingual education.

Linguistic diversity as a proxy for ethnic diversity has been widely studied in the development literature (Alesina and La Ferrara, 2005; Desmet, Gomes, and Ortuño-Ortín, 2020; Desmet, Weber, and Ortuño-Ortín, 2009; Esteban and Ray, 1994; Greenberg, 1956; Reynal-Querol, 2002). Refined and more accurate indicators of diversity than the Herfindhal-Hirschman indicator have been developed. For instance, Reynal-Querol (2002) takes into account the relative size of the groups among each other. In a further version of this paper, I will consider these alternative definitions of linguistic diversity.

Next, I turn to the main language of the community relying on information from the 2009 census. Figure A.7 shows the result. The key result is that Bamanankan, the main vehicular language in Mali, does not drive the results highlighted previously. While there are no significant differences in learning in the local language, I observe that the Kassonkho language is associated with better learning in French. However, as only a small fraction of the population speaks Kassonkho, these results might reflect more a geographical specificity than a linguistic feature.

Rural/ urban status. I also explore whether rural households benefit more from the introduction of local languages, as hypothesized in Section 4.2. Figure A.8 provides the results. I do not observe any differential effect for schooling and learning skills in the official language. Even if it seems that literacy in the local languages increases more in



Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) and (7) are school achievements indicators. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient in the TWFE with sex.

Figure 3: TWFE coefficient estimates of bilingual education effects, by sex

urban areas, the coefficients are not statistically different from each other.

7 Robustness checks

7.1 Relaxing the assumption of homogeneous effects

One of the main caveats of the TWFE analysis in Section 6 is that the median of bilingual education provision differs from one district to another. The underlying assumption is that only intensity matters and that the treatment effect is homogeneous along the bilingual school provision continuum. In this subsection, I consider alternative specifications in which I relax this assumption.

Continuous treatment First, I consider the fraction of bilingual education supply at the commune level instead of its relative intensity as the main treatment. Using the latest development in the DiD literature (Callaway, Goodman-Bacon, and Sant'Anna, 2024), I perform a continuous difference-in-difference analysis using as a treatment variable the share of bilingual schools among the total number of schools in the commune. Figure A.9 shows for every share of bilingual education provision at the commune level the ATT coefficient associated with writing skills as the main outcome. The Figure shows that the ATT is positive for every "dose" of bilingual education. For French skills, it does not vary much according to the share of bilingual schools. For the local language (highlighted in orange), the coefficients vary between 4pp and 6pp but follow a similar trend. Hence, it provides further evidence supporting the TWFE results presented in Section 6.

Heterogeneity analysis. Another way to relax the assumption of homogeneous effect with respect to the median fraction of bilingual schools is to look at differential effects according to the median value used to distinguish high and low-intensity communes. I distinguish between the sample districts for which the median value of BE provision is high and districts where this median value is low. Results are displayed in Figure A.10. The conclusion is close to the previous, as we cannot observe significant differences across groups. Hence, relaxing the assumption of homogeneous impact does not lead us to reject the previous findings.

7.2 Staggered analysis

Precise data on the bilingual education expansion from 1994 to 2011 are available at the district level (see Table A.1 for more details). I leverage this progressive roll-out to perform a staggered differences-in-difference analysis at the district level, using the imputation estimator from Borusyak, Jaravel, and Spiess (2024)[9]. Using the median share of bilingual education throughout the period, I assign for every district a "treatment year": the year for which I observe a share of bilingual education higher than the median. Compared to the previous setting, I introduce a time variation in the treatment, as the treatment year ranges from 1994 to 2005.

Figure A.13 presents the results for the writing skills outcomes. As the level of treatment is now the district and not the commune, I expect the ATE to be less precisely estimated and much lower in magnitude. Indeed, I have only 28 districts in the sample compared to more than 160 communes. Despite this limitation, the results confirm the two previous findings. First, the parallel trends hold for the year prior to the exposure to bilingual education. Then the impacts of bilingual education on writing skills are positive and significant at the 10% level in French and in the local language, with a higher increase for literacy skills in the local language[10]. As one could expect, the effects are much lower compared to the TWFE setting, as I lost precision on which exact population was affected by the linguistic education reform.

7.3 School building

The main objective of the PRODEC reform was to increase school supply by massively building schools. Figure A.1 shows the increase in the number of schools during this period. Using the 2009 census, I focus on the number of children between 7 and 12 (i.e., the official age range to be enrolled in primary schools). I calculate the pupil-school ratio (PSR) as the ratio of this number to the total number of schools in the commune of interest.

[9]Following the procedure suggested in Roth et al. (2023), I prefer the imputation estimator over the Callaway and Sant'Anna (2021) as event studies displayed in Figures A.3, 2 and A.4 show that we should not worry about violation of the parallel trends assumption, and I do not expect important serial correlation between birth cohorts.

[10]Results hold when I take a 95% confidence interval.

To analyze how the school building component interacts with bilingual education, I perform a heterogeneity analysis by comparing communes with a low PSR vs. communes with a high PSR. In the sample, the median Pupil-School Ratio is around 22. Results are shown in Figure A.11. I find that schools with a lower PSR drive the positive results found in Section 6. In particular, school attendance increased by 4pp in communes with more school supply and more bilingual education. It means that minimum criteria for school quality are required for bilingual education to be efficient. It gives insight into potential complementarity between BE and other school inputs.

One concern might be that bilingual education provision (in terms of share of the total school supply) and school supply capture the same variation. In other words, where more schools were built, there are also more bilingual schools than monolingual ones because these new schools would only be bilingual. Using the variation in the school supply between the 1998 and 2009 census, I look at this correlation in Figure A.12. I do not see any correlation between the increase in school supply and bilingual education provision. this suggests that my findings do not capture an increase in overall school supply but BE effects only.

7.4 Schools that switched from bilingual to monolingual education

Leveraging information from the 2011 school start on the bilingual school status, I can identify whether the school still uses the local language as the language of instruction to estimate the differential impacts of the reform along this line. Indeed, in communes where most schools dropped the bilingual curriculum quickly after implementing it, I expect the results to be null or lower: if the schools switched very quickly from bilingual to French-only curriculum, then no birth cohort at all would be fully exposed to BE as the curriculum is supposed to be implemented throughout all the primary grades.

Figure A.14 presents the results. I compare the effects of bilingual education between the sample of communes where at least one school switched from bilingual to monolingual education and the sample of communes where schools continued to follow the language reform[11]. Among the 167 communes, 100 communes had at least one school that switched

[11] I do not use the median of the switching rate at the cutoff point as this median point is zero. Hence, the intensive and extensive analysis are the same here.

from bilingual to monolingual (French-only) education. Aligned with what was expected, I find that positive results in learning and schooling are concentrated among areas with continuity in the linguistic education reform.

7.5 Sensitivity analysis

At the moment, the sensitivity analysis is not complete.

7.6 Other robustness tests

Restrict the sample to villages far from the communal borders. Around 25% of the communes are less than 1km away from the commune's borders. The population in these villages could decide to send their kids to schools in other communes. Table A.4 presents the results when restricting the sample to communes that are at least one kilometer away from the borders of their commune[12]. I find more significant impact coefficients for this subsample, confirming the initial results.

Placebo. Mali is one the countries in sub-Saharan Africa where school attendance is still an issue (World Bank, 2024). Half of the population never went to school in my sample. I expect the reform does not impact people who did not attend school. Figure A.15 displays the results: bilingual education has no effect on the literacy skills of individuals who did not attend school after the reform period. The placebo test also shows that the reform did not affect literacy skills in another language other than the local one.

Potential confounders. Finally, I look at the correlation between potential confounders and the main treatment variables. I specifically study two outcomes that could impact my results: (i) migration and (ii) age at the school entry. Indeed, if bilingual education promotes migration, I would observe a very selected sample. Similarly, if bilingual education attracts children earlier in schools, I would not be able to compare individuals based on their birth year. Table A.5 shows no correlation between treatment

[12] I take the Euclidean distance between the LSMS cluster and the border of the closest commune as my main measure of distance. I do not consider the random displacement of GPS points in my analysis as a limitation, as the random offset procedure ensures that the enumeration area stays within the lowest administrative unit (Michler et al., 2022).

assignment and (i) whether the individual is born in the commune and (ii) age at the school entry (if the individual went to school).

8 Conclusion

More and more African countries use local languages instead of colonial language as the main medium of primary education instruction. However, the literature on such at-scale policies is still scarce.

This paper estimates returns to bilingual education in Mali using implementation data on current bilingual education. The impacts are high, both in terms of learning and schooling. Specifically, girls seem to have the highest returns.

These results have strong policy implications. In particular, they indicate that some requirements are needed for bilingual education to be efficient. Further research is needed to understand the complementarity between basic school inputs and bilingual curricula.

Moreover, introducing local languages in primary education is not politically neutral (Blanc and Kubo, 2024). It suggests future avenues that I intend to take in the future in the study of how this type of education policies shape ethnic identities.

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Appendix

A Data

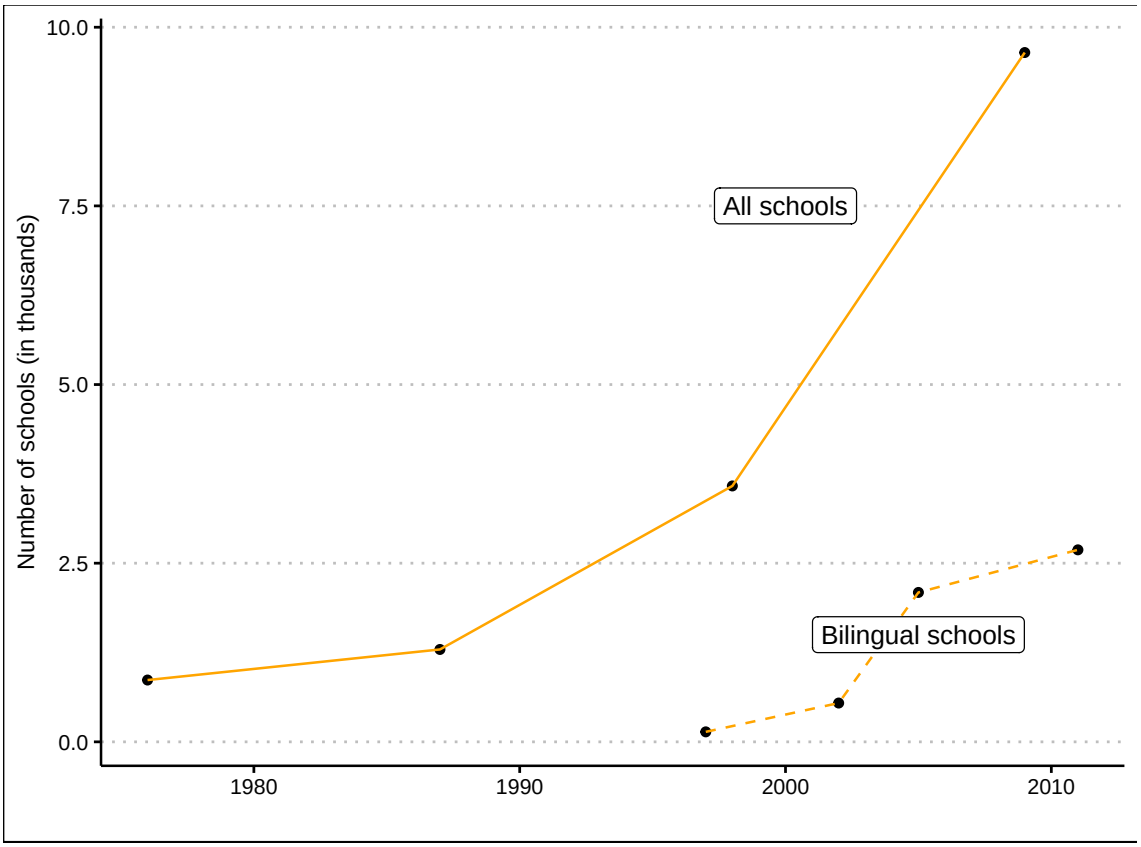


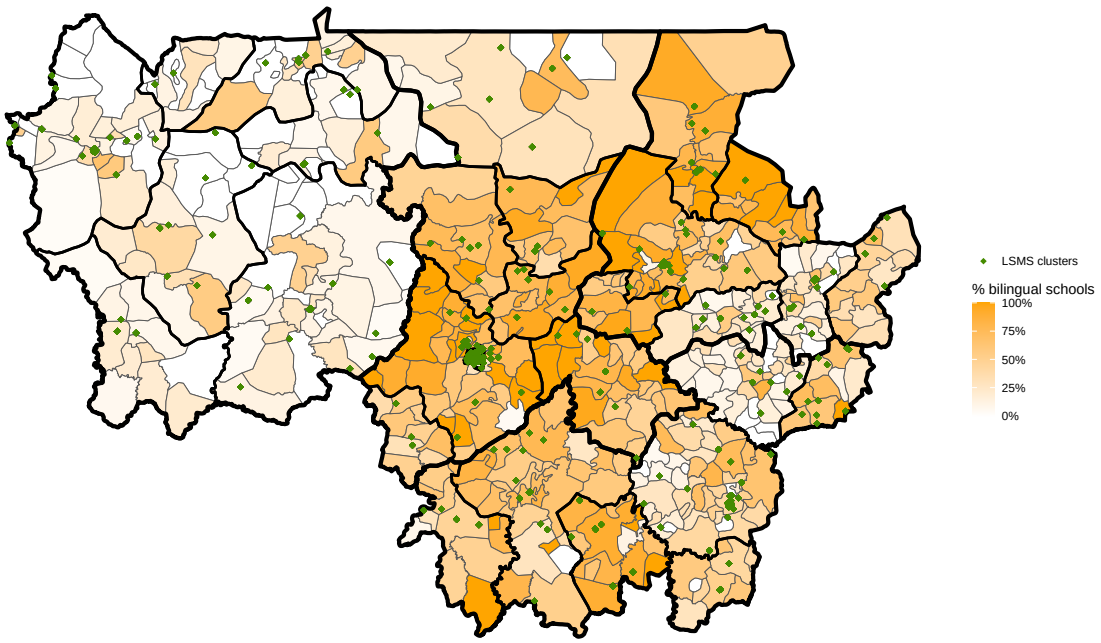
Figure A.1: Time evolution of the number of schools (both bilingual and French-only)

Notes: The orange line represents the school supply, regardless of the languages of instruction used in the school. The school supply was inferred from the national census data. The orange dotted line represents the number of bilingual schools. The number of bilingual schools was retrieved from archival sources from the Bilingual education monitoring section. The four points in time are the only years for which I have accurate data (see Table A.1).

Year	**Geographical level**	**Information**
1994-1997	Cercle	Number of schools per language
2002	Cercle	Number of schools
2005	Region	Number of schools per language
	Cercle	Number of schools
2011	Village	Number of schools, with the status (bilingual curriculum ongoing or not)

Table A.1: Year, geographical level, and information available for bilingual education

Notes: This table gives information about data retrieved from reports documenting the implementation of the bilingual education reform in Mali. "Number of schools" stands for "Number of bilingual schools". "Cercle" stands for district. "1994-1997" stands for "from 1994 to 1997".



Wide black lines represent the regional borders, thin black lines represent the district borders, and gray lines represent the communal borders. The color represents the intensity in the fraction of bilingual schools in each commune: the whiter the commune, the less the provision of bilingual education in the commune. The green dots represent the location of LSMS clusters used in the analysis. This figure maps only the following regions considered in the empirical analysis: Bamako, Kayes, Koulikoro, Segou, and Sikasso.

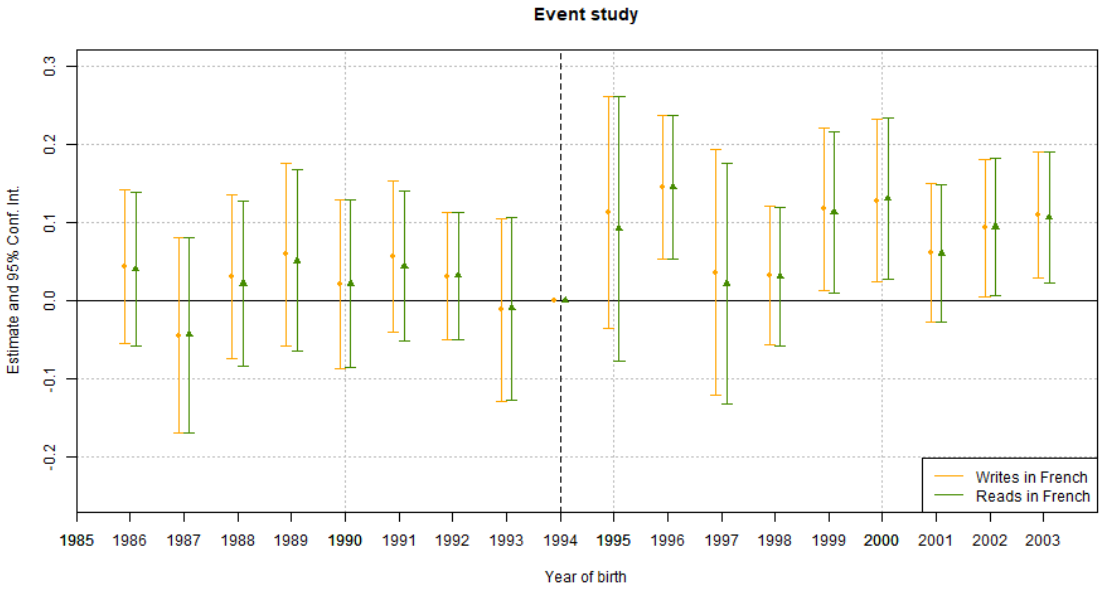
Figure A.2: Bilingual education supply in 2011 and LSMS clusters by commune

Characteristics	Mean	SD	N
A. Individual characteristics			
Female (0/1)	0.56	0.5	7727
Age	22.49	5.29	7727
Muslim (0/1)	0.95	0.22	7727
Urban (0/1)	0.49	0.48	7727
Attended school (0/1)	0.53	0.5	7727
Number of schooling years	3.91	6.13	7727
Literate in French (0/1)	0.53	0.5	7726
Literate in the local language (0/1)	0.13	0.33	7716
B. Commune characteristics			
Number of students in school age	665.92	933.1	149
Number of primary schools	26.62	36.53	149
Share of bilingual schools	0.45	0.32	167
Linguistic HHI	0.46	0.15	148

Notes: (0/1) indicates a dummy variable. SD stands for standard deviation. N stands for the number of non-missing observations for each variable. All descriptive statistics are computed using weights provided in the LSMS survey.

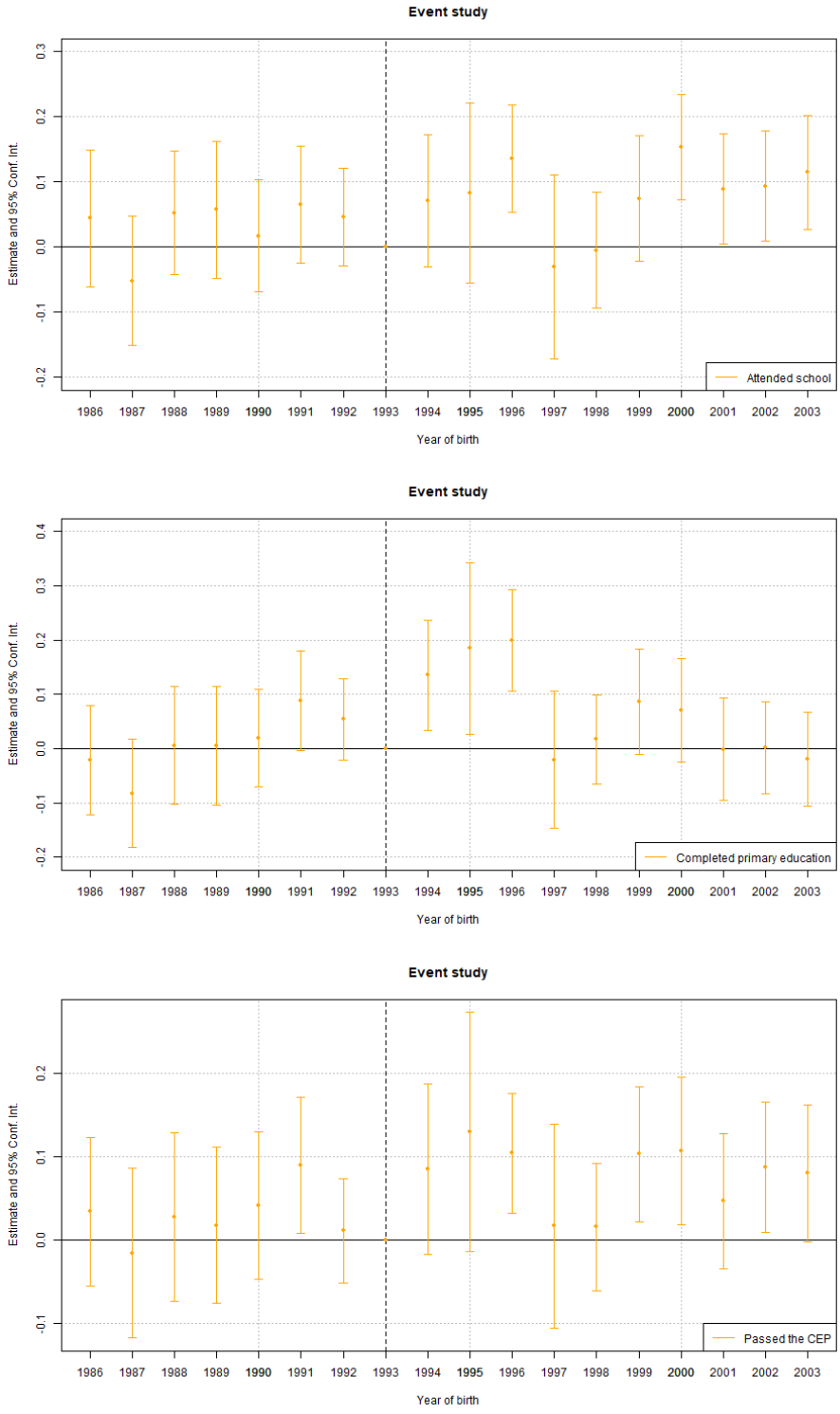
Table A.2: Description of the sample

B Event studies



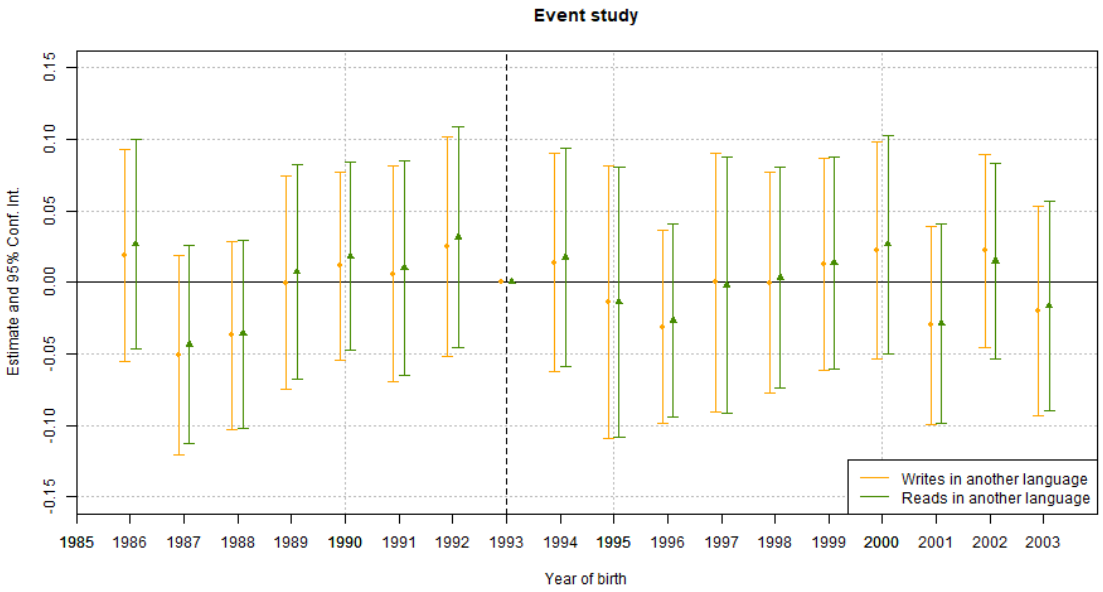
Notes: Point estimates and 95% confidence intervals are derived from an event study regression over the 1985-2003 birth cohorts. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. To obtain these estimates, I perform two distinct regressions: one with whether the individual knows how to write in French as the dependent variable and one with whether the individual knows how to read in French as the dependent variable. I cluster at the LSMS cluster level, which corresponds roughly to the village level. Individuals born in 1993 are the last birth cohort to be taught entirely in French, i.e., not treated, represented by a black dashed vertical line.

Figure A.3: Event study results for literacy in French



Notes: See Figure A.3 for additional notes.

Figure A.4: Event study results for schooling outcomes



Notes: Point estimates and 95% confidence intervals are derived from an event study regression over the 1985-2003 birth cohorts. In addition to time and commune-fixed effects, I use district-fixed effects to capture variation in the median bilingual education share across districts. To obtain these estimates, I perform two distinct regressions: one with whether the individual knows how to write in another language as the dependent variable (in orange), and one with whether the individual knows how to read in another language as the dependent variable (in green). I cluster the standard errors at the LSMS cluster level, which corresponds roughly to the village level. Individuals born in 1993 are the last birth cohort to be taught entirely in French (i.e., not treated), represented by a black vertical dashed line.

Figure A.5: Event study results for literacy in another language

C Additional results

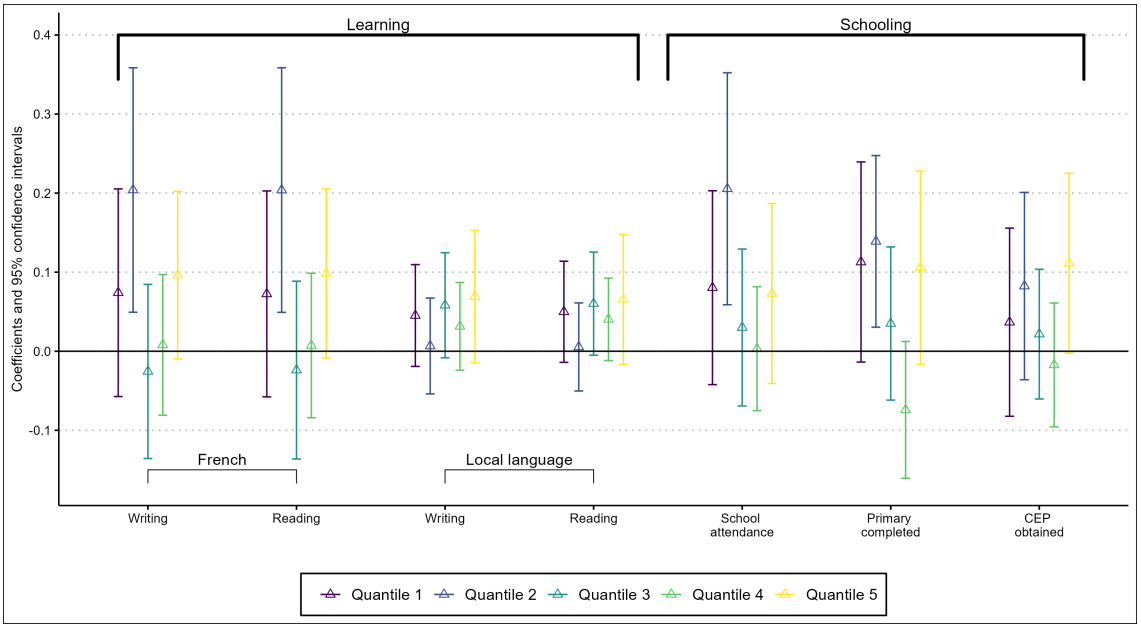
Dependent Variables:	Attended school	Completed primary education	Passed the CEP
Model:	(1)	(2)	(3)
Variables			
Born after 1994	0.137***	-0.034*	0.062***
	(0.019)	(0.020)	(0.016)
High exposed commune	0.027	0.026	0.034
	(0.034)	(0.036)	(0.033)
Born after 1994 × High exposed commune	0.055**	0.037	0.038
	(0.028)	(0.031)	(0.025)
Fixed-effects			
District FE	Yes	Yes	Yes
Fit statistics			
Mean of Y	0.517	0.289	0.316
Observations	7,727	5,191	7,727
R^2	0.10984	0.09429	0.12455

Clustered (grappe) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

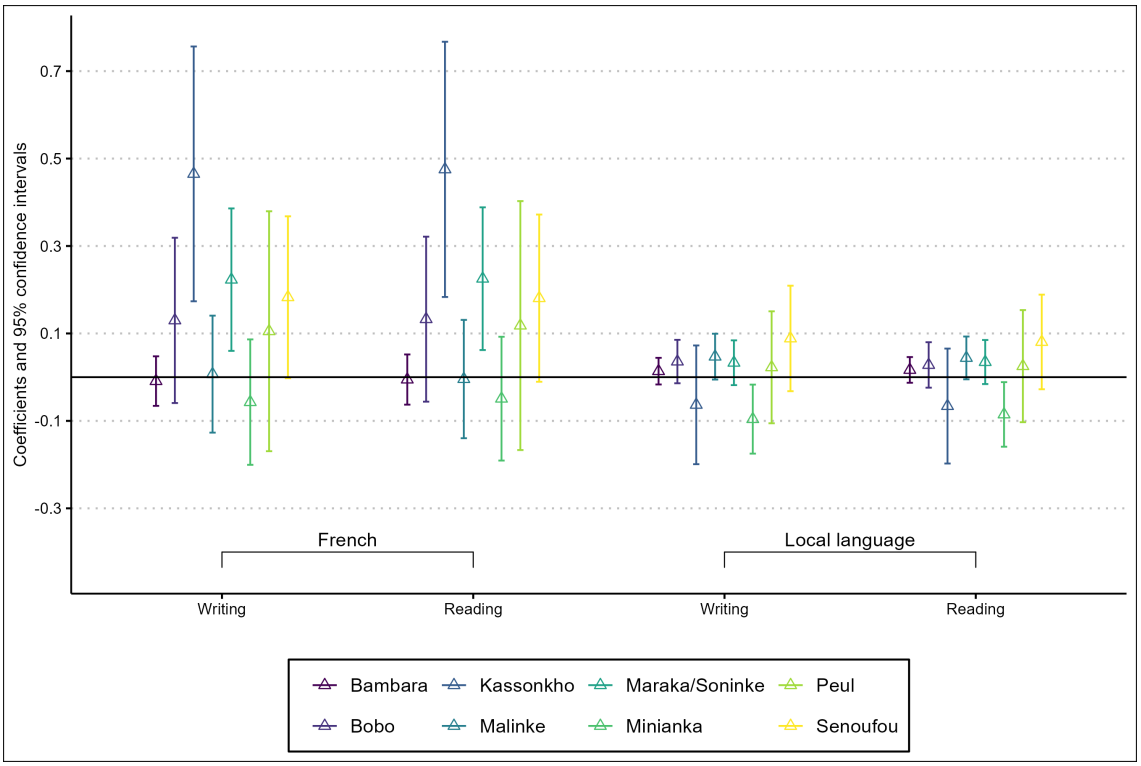
Notes: I use a linear regression specification to obtain the coefficient estimates. In additional to time and commune fixed-effects, I use district fixed-effects to capture the fact that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level, and use household weights given in the LSMS survey. The mean of the outcomes is a weighted mean, using the same weights. The dependent variables are in Column (1) whether the individual attended school, Column (2) whether individual completed the first cycle of primary education, and Column (3) whether the individual succeeded at the mandatory exam at the end of the first primary cycle.

Table A.3: TWFE results on schooling outcomes



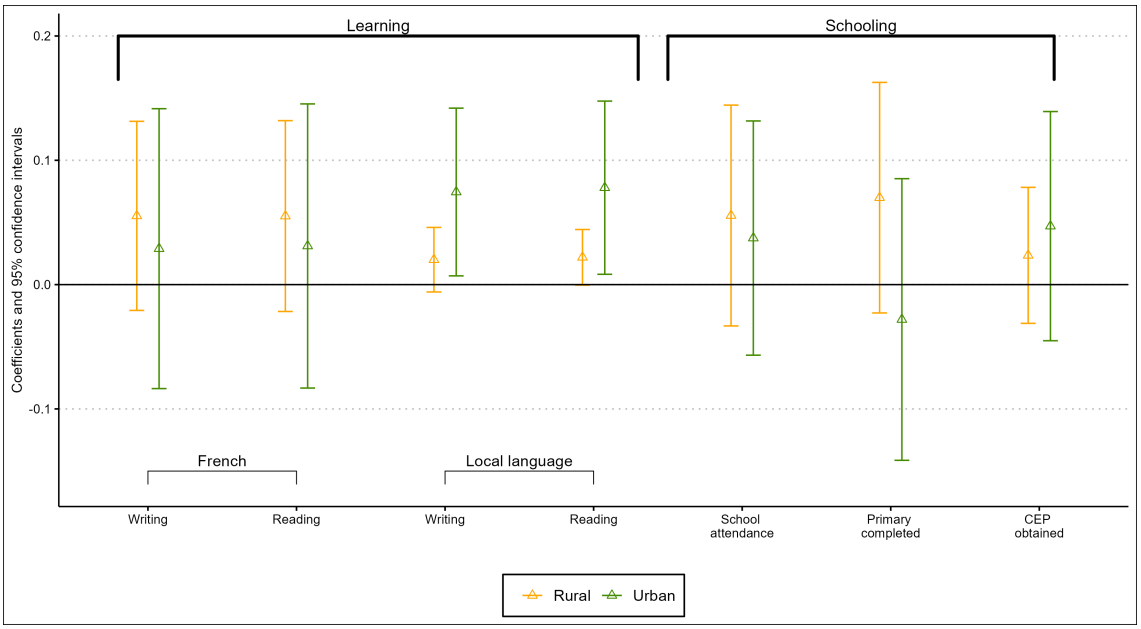
Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) and (7) are school achievements indicators. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a dummy equal to one if the commune has a linguistic Hirschman Herfindhal Index higher than the median.

Figure A.6: TWFE coefficient estimates of bilingual education effects, by linguistic diversity



Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a variable indicating the main language spoken by individuals at the commune level. This variable is taken from the 2009 census, by aggregating the number of speakers for every language at the commune level.

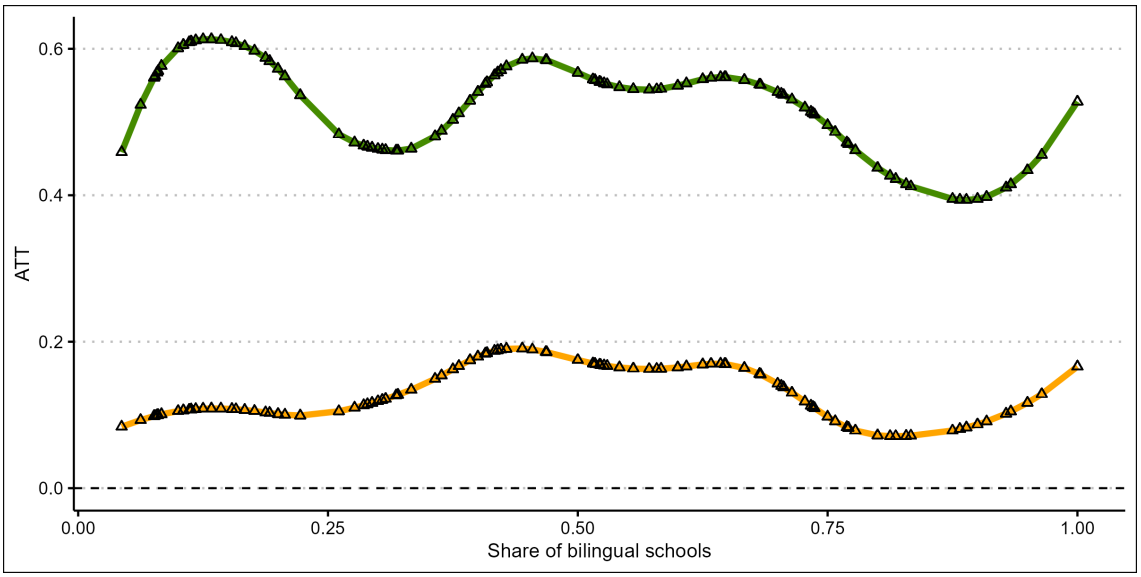
Figure A.7: TWFE coefficient estimates of bilingual education effects, by the main language of the community



Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) and (7) are school achievements indicators. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a variable indicating whether the village is rural or urban.

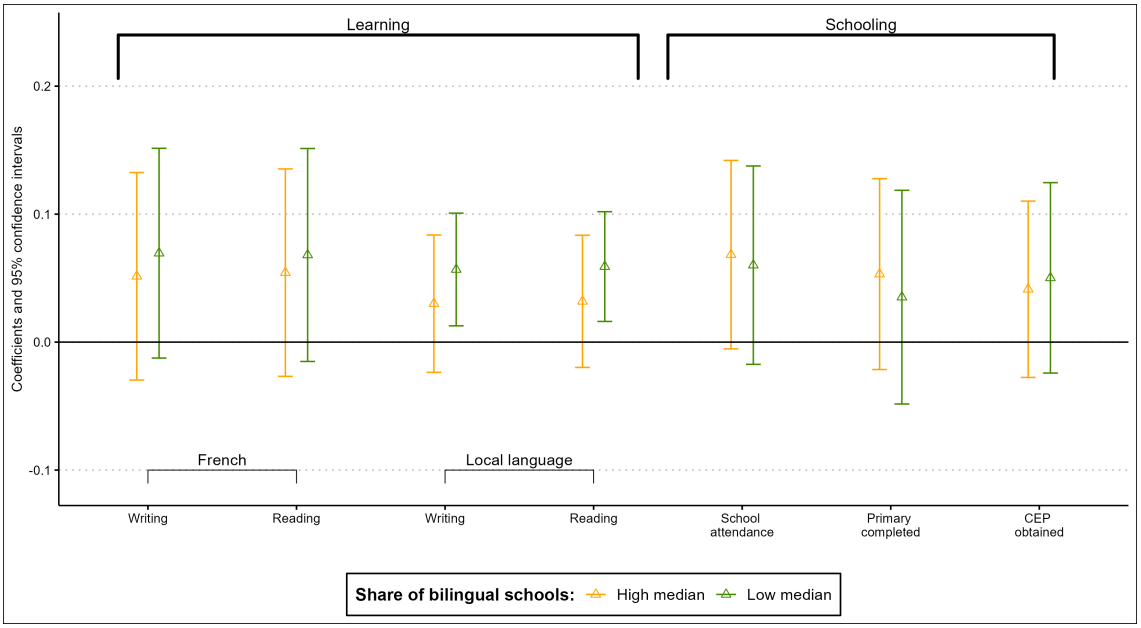
Figure A.8: TWFE coefficient estimates of bilingual education effects, by urban/rural status

D Robustness checks



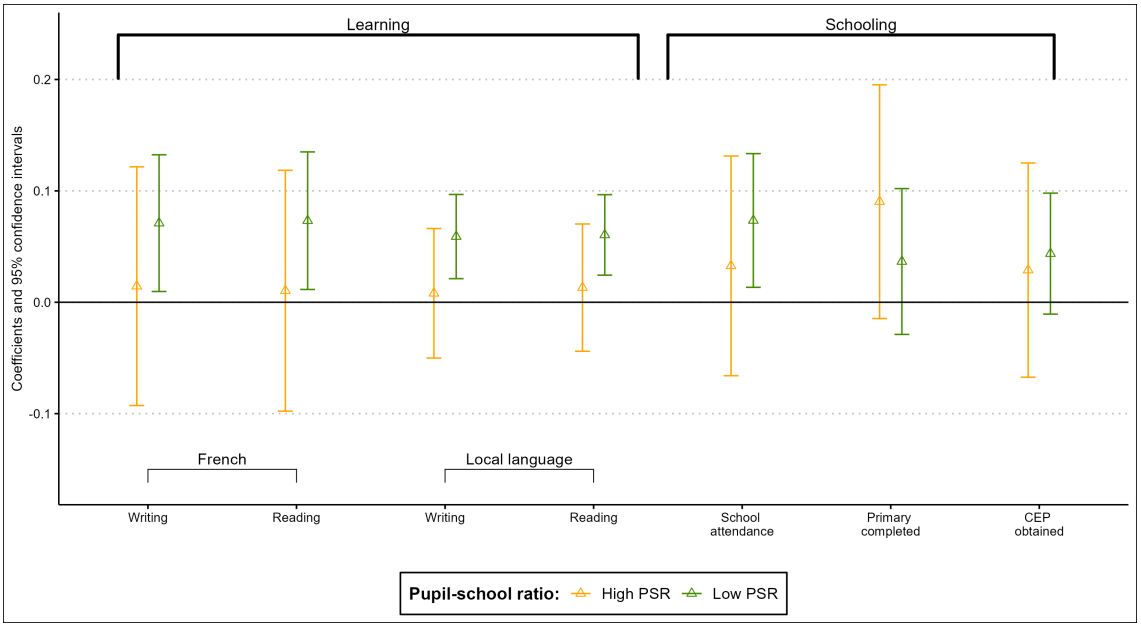
Notes: Point estimates are derived from a continuous DiD regression following the method in Callaway, Goodman-Bacon, and Sant'Anna (2024) The R code used for this regression can be found here. Each point represents the ATT for every share of bilingual education supply. The orange color indicates estimates for writing skills in the local language, while the green color highlights the results for French.

Figure A.9: Continuous DiD for writing skills



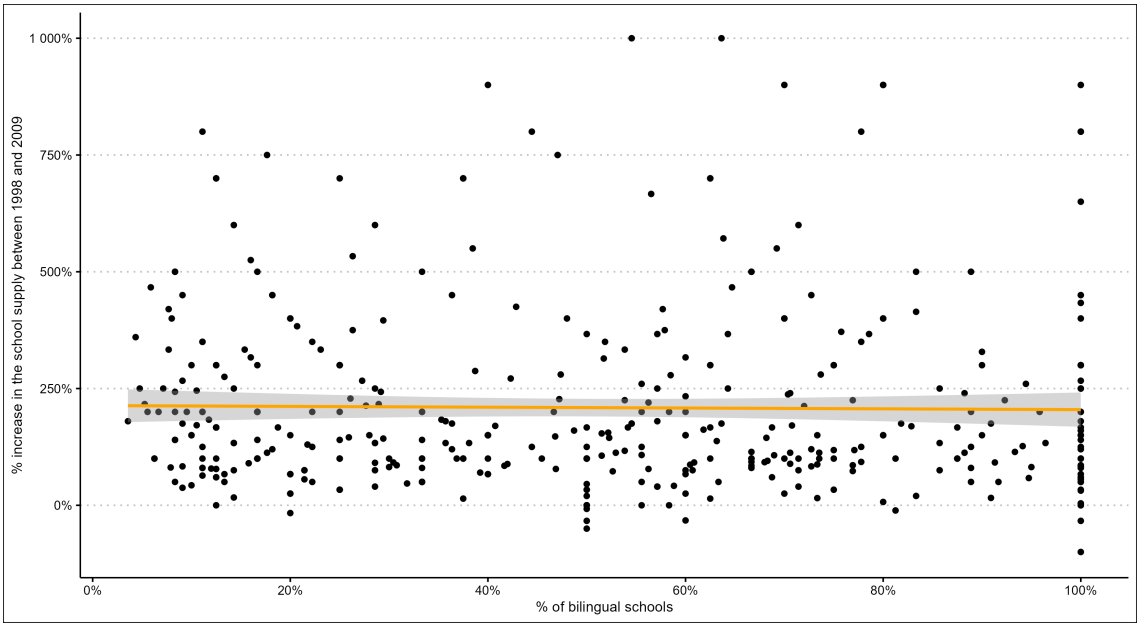
Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) and (7) are school achievements indicators. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a dummy variable indicating whether the median share of bilingual education at the district level is high or low compared to the national median.

Figure A.10: TWFE coefficient estimates of bilingual education effects, by the median share of bilingual education provision



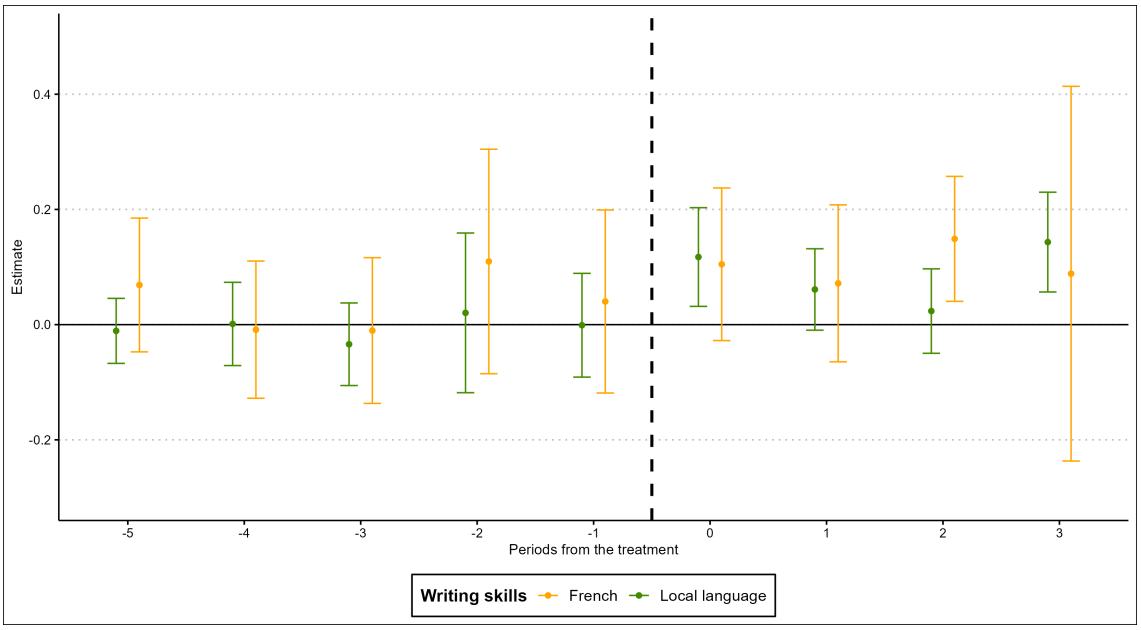
Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) and (7) are school achievements indicators. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a dummy variable indicating the level of the ratio of pupils over schools at the commune level. This variable is taken from the 2009 census, by aggregating the number of children between 7 and 12 at the commune level.

Figure A.11: TWFE coefficient estimates of bilingual education effects, by the number of potential students over the number of schools



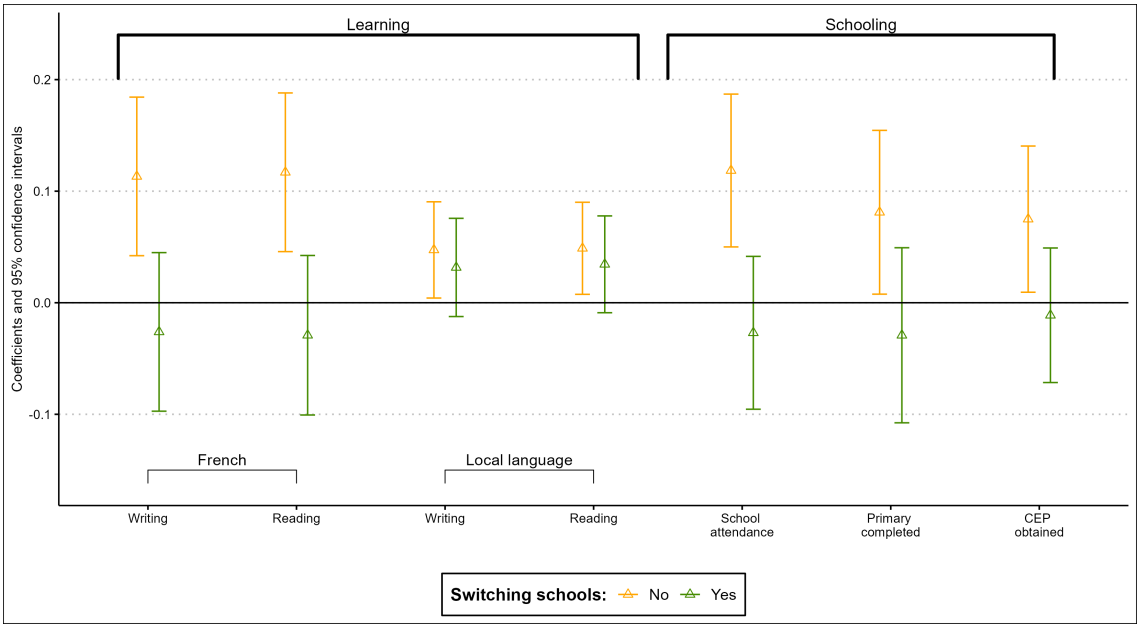
Notes: One black dot corresponds to one commune in the sample. The y-axis depicts the increase in the number of schools from 1998 to 2009 as given in the census, in percentage. The x-axis represents the share of bilingual schools among the total number of schools within the commune. The orange line is obtained from regressing the share of bilingual schools on the increase in schools. The shadowed area represents the 95% confidence interval of the estimated regression coefficient.

Figure A.12: Correlation between school building and bilingual education supply



Notes: Point estimates and 95% confidence intervals are derived from a staggered analysis using Borusyak, Jaravel, and Spiess (2024). The dotted black vertical line indicates the last pre-treatment period. The two sets of points and coefficient estimates are obtained through two separate regressions. The treatment is estimated at the district level. I use region-fixed effects, and I cluster at the LSMS cluster level, which correspondents roughly to the village level.

Figure A.13: Staggered analysis on writing literacy



Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) and (7) are school achievements indicators. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a dummy variable indicating whether the commune had some bilingual schools that switched to the French-only curriculum.

Figure A.14: TWFE coefficient estimates of bilingual education effects, by the continuity in bilingual education

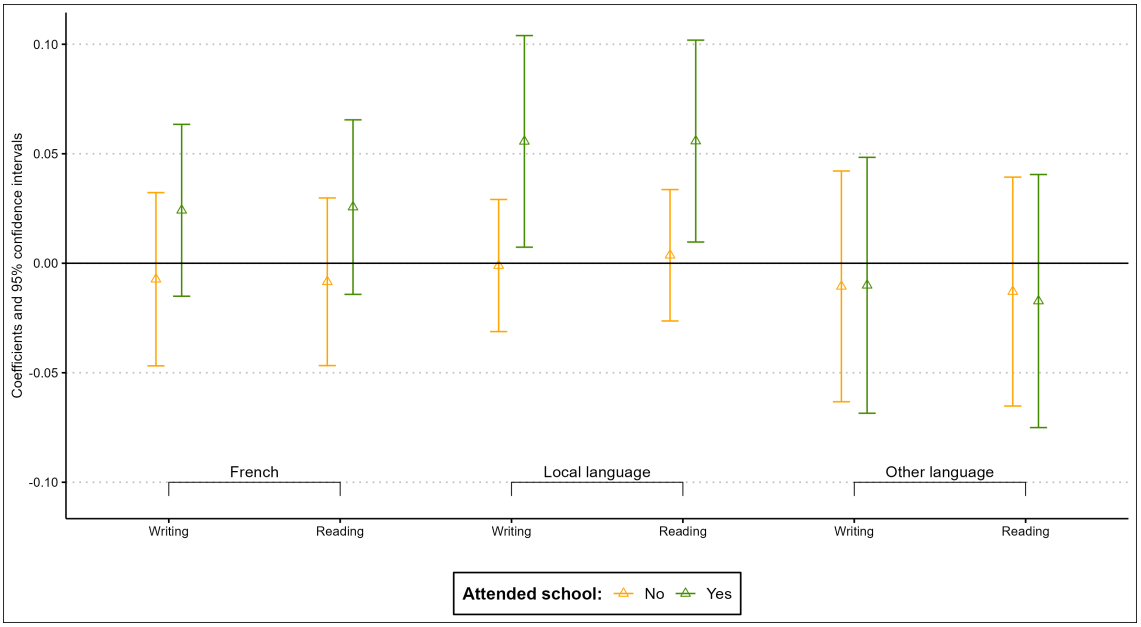
Language tested	Local language		French				
Dependent Variables:	Writing		Reading		Attended school	Completed primary education	Passed the CEP
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
Born after 1994	0.053*	0.040**	0.054*	0.043**	0.055**	0.037	0.038
× High exposed commune	(0.029)	(0.017)	(0.029)	(0.017)	(0.028)	(0.031)	(0.025)
Fixed-effects							
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics							
Mean of Y	0.114	0.109	0.455	0.450	0.478	0.250	0.269
Observations	7,727	7,727	7,726	7,716	7,727	5,191	7,727
R^2	0.13630	0.04706	0.13341	0.04588	0.10984	0.09429	0.12455

Clustered (LSMS cluster) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: I use a linear regression specification to obtain the coefficient estimates. I only present the interaction coefficients in the table. In additional to time and commune fixed-effects, I use district fixed-effects to capture the fact that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level, and use household weights given in the LSMS survey. The mean of the outcomes is a weighted mean, using the same weights. The sample is restricted to villages/clusters that live at least one kilometer away from a communal border, computed as a euclidean distance. The dependent variables are in Column (1) whether the individual knows how to write in the local language (0/1), Column (2) Whether the individual knows how to read in the local language (0/1), Column (3) Whether the individual knows how to write in French (0/1), Column (4) Whether the individual knows how to read in French (0/1), Column (5) whether the individual attended school (0/1), Column (6) whether individual completed the first cycle of primary education (0/1), and Column (7) whether the individual succeeded at the mandatory exam at the end of the first primary cycle (0/1).

Table A.4: TWFE results restricting the sample to communes far from the communal borders



Notes: Point estimates and 95% confidence intervals are derived from a TWFE linear regression on several outcomes: (1) and (2) are writing and reading literacy in French, (3) and (4) in the local language, and (5) (6) in another language. In addition to time and commune fixed effects, I use district fixed effects to capture that the median of bilingual education share varies across districts. I cluster at the LSMS cluster level, which corresponds roughly to the village level. To obtain heterogeneous effects, I interact the DiD coefficient with a dummy variable equal to one if the individual went to school.

Figure A.15: TWFE coefficient estimates of bilingual education effects, by school attendance

Dependent Variables:	Born here (0/1)	Age at the school entry
Model:	(1)	(2)
Variables		
High exposed commune	0.004	-0.003
	(0.003)	(0.041)
Fixed-effects		
District FE	Yes	Yes
Fit statistics		
Mean of Y	0.989	6.60
Observations	7,727	4,121
R^2	0.00713	0.08627

Clustered (LSMS cluster) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: I use a linear regression specification to obtain the coefficient estimates. I use district fixed effects, and I cluster at the LSMS cluster level, which corresponds roughly to the village level, and use household weights given in the LSMS survey. The mean of the outcomes is a weighted mean, using the same weights. The dependent variables are in Column (1) whether the individual was born in the surveyed village and in Column (2) the age when the individual started school for individuals who went to school (explaining the decrease in the number of observations).

Table A.5: Correlation between treatment and potential confounders