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Distributional Association of Preschool Education and Learning Outcomes in Primary School in Togo

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Abstract

The objective of this research is to examine the distributional association of preschool education with the learning outcomes of primary school students in Togo. To do so, this research uses unconditional, conditional, stratum fixed-effects conditional quantile regressions and data from CONFEMEN Program for the Analysis of Educational Systems (PASEC) survey conducted in 2019. Additional robustness tests, based on stratum fixed-effects OLS estimation and propensity score estimators (IPW, AIPW, and IPWRA), were conducted to ensure the stability of the results. The results show a positive association between access to preschool education and school performance, particularly in Grade 2. In Grade 2, preschool attendance is associated with score gains of 0.233 standard deviation at the 10th quantile, 0.178 at the median, and 0.268 at the 90th quantile in reading. The results are similar for mathematics. In Grade 6, this positive association persists in the middle and upper quantiles for both subjects. This suggests that students in these segments of the distribution are more likely to benefit from a higher-quality education and a favorable family environment. These distributional associations suggest that preschool education disproportionately benefits higher-performing students in the upper quantiles, particularly at Grade 6, with implications for how policymakers should target early childhood investments in Togo.

Keywords: preschool education; quantile regression; learning outcomes; primary school; Togo. *JEL codes:* A21, I21, O12

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1 Introduction

Around the world, governments are investing heavily in early childhood development (Elango et al., 2015; Vygotsky, 1967, 1978). An important aim of these investments is to ensure that children from all family backgrounds benefit from a warm and stimulating environment at home and in other care settings. These investments are generally based on two principles: First, hundreds of studies document the significant gaps that exist between disadvantaged and more advantaged children in terms of socio-emotional and school development (Duncan and Murnane, 2011). Secondly, the return on investment in skills during early childhood can be particularly high, as this is a period when children's brain development is particularly rapid and malleable. Also, children's early life experiences shape the architecture of their developing brains and can affect their skills and social-emotional development throughout their lives (National Scientific Council on the Developing Child, 2010). The theoretical framework proposed by Cunha and Heckman (2007) highlights the critical role of early interventions in the formation of human capital, positing that their effects are more lasting because they reinforce key skills for future learning and increase the productivity of subsequent educational investments. This approach underscores the importance of identifying and developing, from a very young age, the fundamental skills, whether cognitive or non-cognitive, that shape learning trajectories. Although the quality of subsequent educational environments may influence the final level of skills, the model suggests that an initial advantage resulting from an effective early intervention tends to persist, or even grow over time, even in diverse educational contexts.

A growing literature documents that preschool effects often fade out within a few years of primary school entry (Jakiela et al., 2024; Blanden et al., 2022; Bailey et al., 2017). For example, Jakiela et al. (2024) found that the gains from preschool do not persist beyond age 4 in rural Kenya. Magnuson et al. (2007) also note that preschool education in the United States is associated with better reading and math skills upon entering primary school, but that these effects fade for most children by the end of first Grade. Similarly, Berlinskia et al. (2009) found in Argentina that preschool attendance has a positive effect on performance scores in Spanish and mathematics in third Grade only. However, Baker et al. (2019) in Quebec and Gupta and Simonsen (2010) in Denmark conclude that preschool attendance has no impact on children's cognitive and non-cognitive skills. In Uganda, after three years of mathematics instruction, nearly half of the students who had received preschool education were unable to rank numbers from 0 to 999 (Bold et al., 2017). At the same time, other studies conducted in Cambodia and the United Kingdom indicate that their results depend on the context (Berkes et al., 2024; Cattan et al., 2024). This suggests that current studies on this topic are not unanimous, revealing a divergence in contextual interpretation. Little is known about the persistence of the effects

of preschool education in French-speaking West Africa, and even less is known about student performance based on their place of residence.

In most regions[1], participation in early childhood education has increased (World Bank, 2023), with 61% of the world's children enrolled in preschool education in 2020 against 46% in 2010. However, in sub-Saharan Africa, almost half of preschool children were not enrolled in school in 2020, and the region faces the challenge of high population growth, which puts additional pressure on countries hoping to increase preschool enrolment rates. As such, wise investments in the physical, cognitive, linguistic and socio-emotional development of young children, from birth to primary school entry, are essential to set them on the path to greater prosperity and to help countries be more productive and competitive in a rapidly changing global economy (Jakiela et al., 2024; World Bank, 2023). A wealth of evidence confirms that investment in quality programs that support children's health, nutrition and early learning can improve learning outcomes and ultimately increase adult wages and productivity (García et al., 2020; Blau and Currie, 2006). Finally, participation in early childhood education is an important starting point for setting children on the path to success throughout their schooling. Clearly, progress has been made, but much remains to be done to ensure that every child enters preschool to acquire early socialization and skills for school and life, particularly in low-income countries (LICs).

Evidence from LICs in Sub-Saharan Africa remains limited, largely context-specific, and focused primarily on average rather than distributional effects, where access to preschool education remains one of the lowest in the world. One of the difficulties in estimating the impact of access to preschool education, particularly in LICs, is that there is rarely a systematic collection of learning outcomes at ages where schooling is not compulsory, making it difficult to compare those who attend preschool with those who do not. Existing evidence suggests that preschool programs supported by governments and NGOs in Africa have positive effects in some contexts (Martinez et al., 2017), but not in others (Blimpo et al., 2022). In most LICs in sub-Saharan Africa, primary education is generally of poor quality, and access to preschool education can have minimal impact on children's learning outcomes in primary school (Wang et al., 2024; Bietenbeck et al., 2019; Bold et al., 2018). Still, in many countries including in Togo, access to and quality of preschool education remain an important aspect of education policies and programs aiming at improving primary school outcomes (Jakiela et al., 2024; Wang et al., 2023; Blimpo et al., 2022).

Preschool enrolment rate in Togo remains relatively low, particularly in rural areas. A total of 58% of preschool children are not enrolled in nursery school, out of the country's 1.2 million children under the age of 5 (World Bank, 2023). Regarding education quality and student

[1] In low-income countries, preschool enrollment has increased across the board over the past 25 years (Bold et al., 2017). However, a large proportion of children in these countries complete primary school without mastering basic reading, writing, and numeracy skills (Hungi et al., 2010; PASEC, 2014, 2019)—a situation that UNESCO (2013) has described as a "global learning crisis."

outcomes in primary school, the latest PASEC2019 report shows that among the low-income countries in French-speaking Africa that took part in the PASEC2019 assessment, the proportion of students without sufficient language skills at the start of primary school was highest in Togo (75.6%), compared with other countries such as Burkina Faso (65.8%), DRC (58.4%) and Niger (55.7%). Similarly, Togo is the only country where less than 50% of students are above the threshold of proficiency in mathematics at the start of primary school. The same trends are observed at the end of primary school. Overall, Togo has the worst results in primary school according to the PASEC 2019 report, although it posts the highest preschool enrolment rate (40%) compared to other PASEC countries: 12% in Burkina Faso, 24.2% in Burundi, 21.2% in Côte d'Ivoire, 35.9% in Madagascar, and 32% in Niger. For all that, given that preschool education is not yet compulsory in Togo, this country offers a fertile ground for rigorously examining the relationship between preschool education and student performance in primary school, and for formulating recommendations that could help other low-income countries in French-speaking West Africa improve preschool education and student performance in primary school.

The objective of this research is to examine the distributional association of preschool education with the learning outcomes of primary school students in Togo. It uses a combination of unconditional quantile regression (UQR), conditional quantile regression (CQR) and stratum fixed-effects CQR models to capture the full distribution of the associations of preschool education and allow a more granular analysis of the differential associations of preschool on student performance levels. This approach also contributes to a better understanding of the dynamics of educational inequalities related to access to preschool. Furthermore, research focusing on French-speaking West African contexts in low-income countries, where the role of the student's residential environment in access to preschool education and its benefits remains understudied, is still insufficient. This lack of empirical data underscores the need for research using robust econometric methods to better examine the differential associations of preschool education according to students' place of residence.

This study thus contributes to existing literature in several ways. First, this paper contributes to the growing literature on persistence and fade-out of early childhood education effects. It provides the first evidence from Francophone West Africa that preschool attendance is positively associated with learning outcomes through Grade 6 — consistent with persistence of early gains and not the fade-out documented in Kenya (Jakiela et al., 2024) and England (Blanden et al., 2022). Second, this study is the first to rigorously examine the distributional association between preschool education and the school performance of primary school students in Togo, using UQR, CQR, and stratum fixed-effects[2] CQR models. This distributional approach reveals that persistence is concentrated in the middle and upper quantiles, consistent with cumulative skill formation theory (Cunha and Heckman, 2007). Third, it enriches existing literature by

[2] Stratum-Golfe Lomé, Stratum-Kara, Stratum-Maritime, Stratum-Plateaux and Stratum-Savanes.

examining the distributional associations between preschool education and school performance in Grades 2 and 6, while controlling students' place of residence. Existing studies do not always account for this factor, which limits our understanding of the mechanisms through which preschool education influences school performance. Fourth, this study is timely, tailored to the Togolese context, and contributes to the improvement of preschool education policies in Africa. More importantly, this paper contributes to the debate on whether early childhood investments generate lasting cognitive benefits in low-income settings.

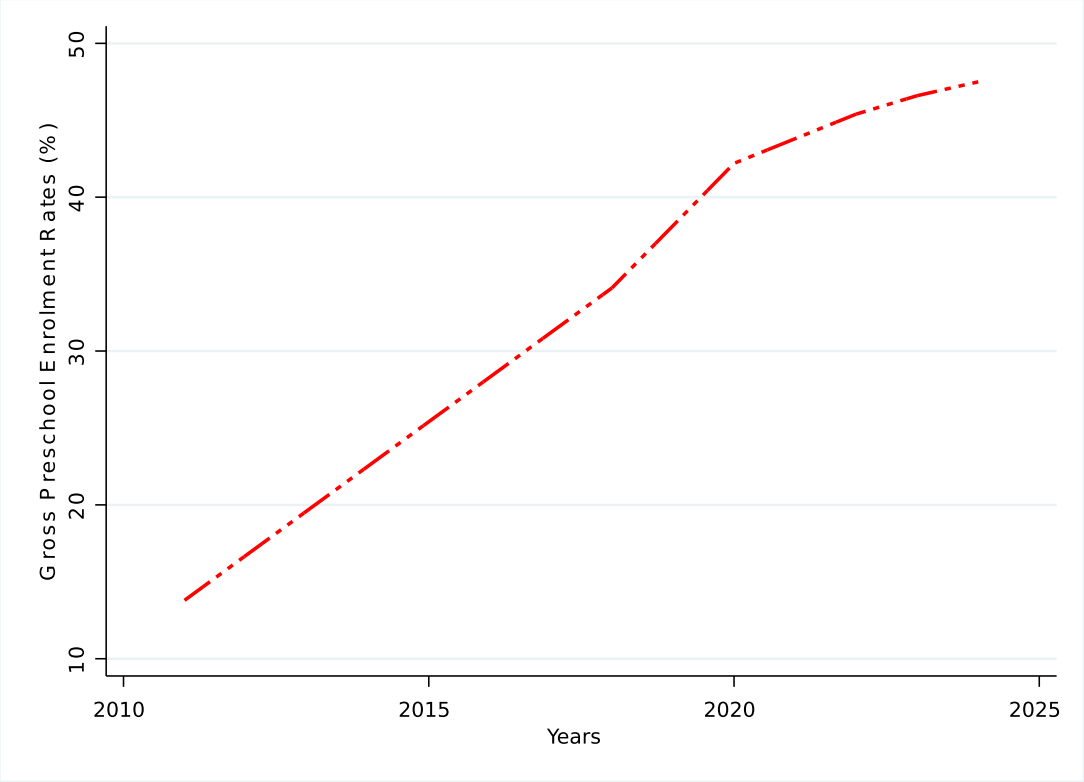
The remainder of the paper is organized as follows: the next section (section 2) presents an overview of the current state of Togo's preschool and primary education system, followed by the literature review - lessons from literature in section 3, and the methodology in section 4. Section 5 presents and discusses the results, section 6 presents the robustness check of the results, and the final section (section 7) presents the conclusion and policy implications.

2 Overview of the education system in Togo: preschool and primary education

Preschool education is a key priority for the Togolese government, which has set itself the goal of improving children's educational attainment (UNICEF, 2020; PASEC, 2014, 2019). Figure 1 shows the evolution of gross enrolment rates in preschool education, and we see that these rates have risen sharply in recent years between 2010 and 2025. This increase is mainly driven by students enrolled in the public and private sectors, with an average annual increase of 2.4% for the public sector and 4.2% for the private sector. Although public preschool enrolment has been free since 2008, there are more students enrolled in private than public pre-schools. Preschool education in Togo lasts two (2) years and covers children aged 4 and 5 (UNICEF, 2020). Preschools (also referred to as nursery schools throughout the paper) generally offer around six (6) hours a day (Monday, Tuesday and Thursday) and four (4) hours a day (Wednesday and Friday) of teaching, covering subjects such as character reading, writing, number and geometry recognition (math and graphics), music together, drawing, sport and play kits to get the children to play. Classes are taught in French and run throughout the day. These public and private nursery schools are predominantly in urban areas.

After pre-school, children enter primary education, an essential stage in the Togolese education system, the aim of which is to equip children with the fundamental skills of reading, writing and arithmetic (UNICEF, 2020; PASEC, 2019). Figure 2 shows the evolution of gross enrolment rates in primary education. These rates declined between 2010 and 2025. This may be an indication of the number of children of primary school age increasing faster than the number of seats available. Added to this are persistent household poverty, child labor in rural areas (agricultural

Figure 1: Changes in preschool enrolment rates between 2010 and 2025



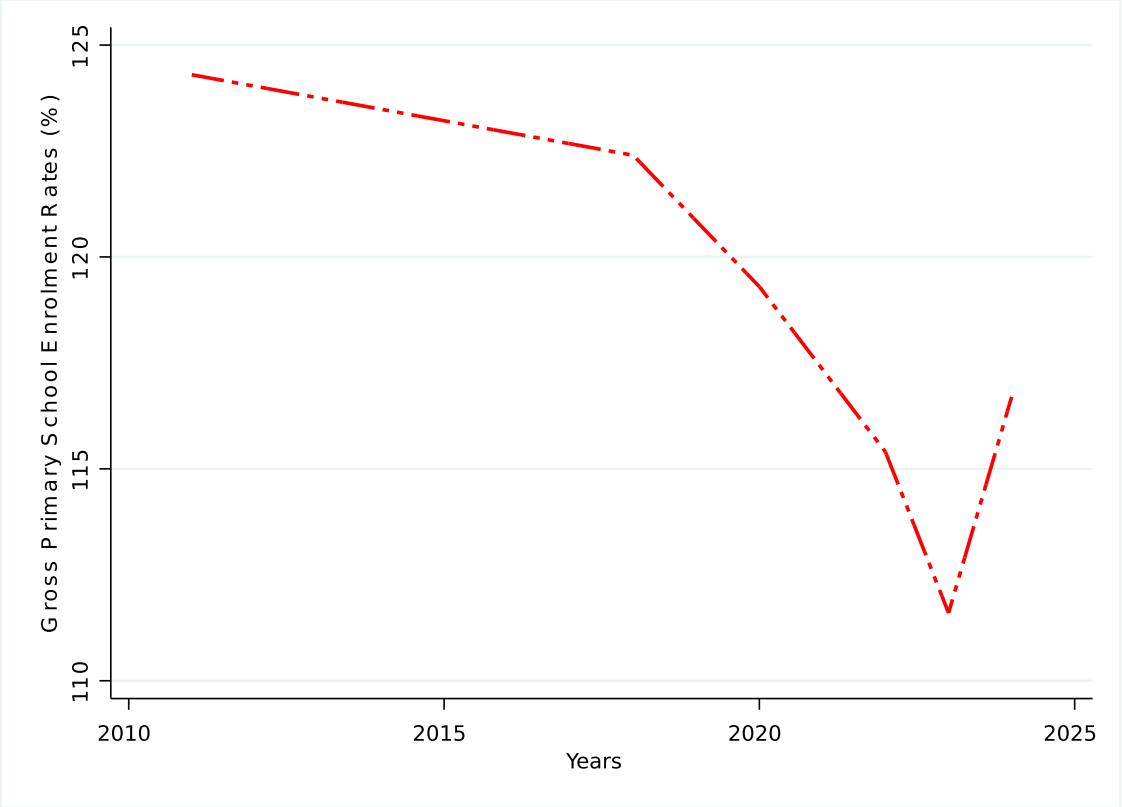
Notes: Source: World Development Indicators (2025)

activities), insufficient quality infrastructure, low funding for education, early marriage or pregnancy, early drop-out and lack of qualified teachers (UNICEF, 2020). Primary school generally starts at the age of 6. It lasts six (6) years and covers children aged 6 to 11. What's more, despite Togo's policy of free public primary education since 2008, parents continue to bear significant costs for their children's schooling. "*Parallel contributions*[3]" perfectly illustrate the principle of cost-sharing between the state and parents and still make schooling too expensive for low-income households which are sometimes forced to select which children to enroll or keep in school (QUIBB, 2016). These parallel contributions represent a prohibitive cost for parents and limit the possibility of educating children, particularly girls from the poorest households, and almost 10% of children still do not reach the end of primary school (UNICEF, 2020).

Togo took part in the PASEC2014 assessment along with nine other French-speaking African countries. This assessment measures students' skill levels at the start (grade 2) and end (grade 6) of primary schooling in two disciplines: language of instruction (French) and mathematics. The

[3] Parallel contributions in preschool and primary education in Togo, although they may occasionally contribute to improving infrastructure and acquiring teaching materials, constitute a significant financial barrier for vulnerable households. They exacerbate inequalities in access, particularly between urban and rural areas, and risk compromising the schooling of children from disadvantaged families. In the absence of a clear regulatory framework and transparency mechanisms, they weaken school governance and may distract authorities from the need for equitable and adequate public funding.

Figure 2: Trends in primary school enrolment between 2010 and 2025



Notes: Source: World Development Indicators (2025)

data show that Togolese students encounter numerous learning difficulties right from the start of primary school. Togo's average score in language (473.6) and mathematics (474.5) is below the 500-point average obtained by all ten countries participating in the assessment. Nearly 79.9% of students do not have the knowledge and skills required in French to continue their schooling in good conditions, while in mathematics, this is the case for nearly 58.7% of students. Also, more than 70% of the students assessed in PASEC2019 do not have sufficient skills to continue learning without difficulty in secondary school. This means that the situation has worsened between PASEC2014 and PASEC2019. Thus, the acquisition of skills by children in primary school remains a major challenge for Togo's education sector. For example, according to the PASEC2019 report, at the start of primary school, 76% of students were below the sufficient threshold in language and 53% are below the sufficient threshold in mathematics, while at the end of primary school, 61% of students are below the sufficient threshold in reading and 63% below the sufficient threshold in mathematics. Educational poverty in Togo is estimated at 86% (UNICEF, 2020), which means that 86% of Togolese children at the end of primary school have not mastered reading. Awareness of this reality has led the Togolese education authorities to take several measures, including the opening of six teacher training colleges (ENI) in Tabligbo,

Notsè, Adéta, Sotouboua, Niamtougou and Dapaong. A 7th ENI, in Mango, will train only early childhood educators.

Although preschool enrolment in Togo has increased significantly in recent years, primary education continues to face declining enrolment and weak learning outcomes. This contrast suggests that expanding access to preschool alone does not automatically translate into improved performance in primary school. Persistent structural challenges such as poverty, limited infrastructure, and shortages of qualified teachers continue to hinder students' learning and progression in the primary education system.

3 Preschool education and learning outcomes: lessons from literature

The theory of dynamic complementarity[4] suggests that early investments are more likely to lead to lasting improvements in early childhood development (Cunha and Heckman, 2007). Heckman (2008) demonstrates that early investments in early childhood generate higher returns than later investments. This is linked to the multiplier effect of skills acquired during the early years on future performance. High-quality preschool education reduces initial inequalities and enhances children's economic prospects in adulthood. Furthermore, the theory of cumulative skills tells us that school success in primary school depends heavily on the foundations laid during early childhood. Cognitive skills (reading, reasoning) and non-cognitive skills (discipline, motivation) interact to improve performance. However, attachment theory suggests that children's developmental needs change significantly across the stages of early childhood. Indeed, it defines the attachment phase as the period from 6 months to 2 years. During this phase, early separation from the primary caregiver, usually the mother, can cause stress and anxiety in the child, with potentially negative effects on their development (Bowlby, 1973).

3.1 Average Effects of Preschool Education on Primary School Performance in Low-Income Countries

Empirical data from low- and middle-income countries indicate that preschool attendance is generally associated with better cognitive outcomes. Indeed, the empirical findings of Jakiela et al. (2024) in Kenya suggest significant short-term gains. In other words, 3-year-olds living near a preschool demonstrate better vocabulary skills; however, this pattern is not observed among children older than 4. Furthermore, Berlinski et al. (2009) show that preschool attendance has a positive effect on standardized test scores in Spanish and mathematics in third grade only in Argentina. Furthermore, Duncan and Magnuson (2013), Yoshikawa et al. (2013), and Nores and

[4] This approach, developed by Cunha and Heckman (2007), highlights that early investments strengthen children's ability to take full advantage of subsequent learning.

Barnett (2010) show that children who have received preschool education perform better upon entering primary school than those who have not. More importantly, Bietenbeck et al. (2019) find that children who attended preschool have comparable school levels and score approximately 0.10 standard deviations higher on standardized tests in Kenya and Tanzania. They also have a 3-percentage point higher chance in Kenya and a 5-percentage point higher chance in Tanzania of acquiring basic reading, writing, and math skills.

Studies in sub-Saharan Africa consistently show positive correlations, on average, between preschool attendance and early cognitive development. In Zambia, McCoy et al. (2017) found statistically significant improvements in cognitive performance at school entry among children who had received preschool education. Similarly, results from the Young Lives study indicate that in Ethiopia, children living in urban areas who attended preschool demonstrated better cognitive performance at age eight than their non-schooled peers (Kim, 2022; Woldehanna, 2016; Woldehanna and Gebremedhin, 2012). Additional data from a small-scale preschool intervention in the Oromia region show that participation in programs, whether standard or high-quality, is associated with significant progress in reading, writing, and arithmetic at ages six and seven (Dowd et al., 2016). Overall, these results confirm the average positive effects of preschool education on early learning, particularly regarding fundamental cognitive skills, even though the persistence of these gains over time remains unclear. Despite consistent evidence of short-term benefits (Jakiela et al., 2024; Berlinski et al., 2009), the literature increasingly advocates for a contextualized understanding of the effects of preschool education, rather than universal claims regarding short-term benefits. More importantly, the integration of data on how investments in preschool education translate into school outcomes in primary school in low-income Francophone contexts remains limited, particularly due to contextual constraints. This study addresses this gap by examining the relationship between preschool education and school performance in Togo.

3.2 The Debate on the Fade-Out of Early Learning Gains and Their Persistence

Although attending preschool leads to significant progress from a very young age, numerous studies document a gradual decline in these gains over time, a phenomenon commonly referred to as “fade-out” (Blanden et al., 2022; Bailey et al., 2017; Barnett, 2010). This observation is particularly relevant in developing countries, where structural constraints, such as overcrowded classrooms, a limited number of teachers, and insufficient teaching materials, can undermine the continuity of skill development (Wolf et al., 2017). Longitudinal studies conducted in both developed and developing countries show that the advantages observed in early assessments often converge within a few years of primary schooling (Currie, 2001; Magnuson et al., 2007). In Kenya, Jakiela et al. (2024) note that the progress observed in three-year-olds tends to fade during primary school. This gradual disappearance is often attributed to a “catch-up” effect

among children who did not attend preschool, as well as to school curricula that prioritize easily replicable early skills, thereby limiting their long-term impact (Bailey et al., 2017). In low-resource settings, weak education systems can accelerate the erosion of advantages gained in early childhood (Wolf et al., 2017). However, interpreting these findings as indicating a gradual decline in these benefits may underestimate their long-term impact. Furthermore, the meta-analysis by Bus and van IJzendoorn (1999) on early phonological awareness training reveals substantial effects on children's initial reading skills, but much weaker effects on reading skills in the subset of studies with a follow-up assessment 18 months, on average, after the end of the programs. Unfortunately, this analysis does not provide information on the persistence of these effects in the long term.

Furthermore, convergence in test scores does not imply convergence in underlying abilities; initial advantages may re-emerge in subsequent school achievement, labor market outcomes, and behavioral adaptations (Deming, 2009; Chetty et al., 2011). Other studies identify the mechanisms underlying these lasting effects, including skill development processes, priming effects that influence educational trajectories, and institutional complementarities, which depend on the quality of subsequent schooling (Bailey et al., 2017; Cunha and Heckman, 2007). Other studies show that early learning gains can re-emerge later in life through improved educational attainment or behavioral adjustments, even as the intermediate effects of test scores fade (Deming, 2009; Chetty et al., 2011). Consequently, the debate on the decline in learning gains is shifting from a narrow focus on short-term cognitive outcomes toward a broader assessment of long-term human capital accumulation. Evidence shows that the persistence of early learning gains depends on supportive environments (Magnuson et al., 2007). High-quality primary schools amplify the benefits of preschool education, while low-quality schools contribute to a rapid erosion of skills (Bailey et al., 2017; Wolf et al., 2017). In low-income settings, particularly in French-speaking sub-Saharan Africa, it appears that weak school systems further accelerate the erosion of early learning gains, as the initial benefits are not sufficiently reinforced (Wolf et al., 2017). Thus, the hypothesis of gradual attenuation challenges the notion of lasting cognitive benefits associated with investments in preschool education. This research addresses this gap by analyzing how initial investments in preschool education can influence the durability of early learning gains.

3.3 Distributional Effects of Preschool Education: Who Benefits Most?

Beyond average effects, some studies highlight significant heterogeneity in the impacts of preschool education depending on performance levels, raising crucial questions of equity and policy targeting (Jackson and Page, 2013). Two contrasting hypotheses emerge. The compensatory effect hypothesis suggests that children with lower initial abilities benefit most from preschool education because of their greater potential for improvement (Jackson and Page,

2013; Engle et al., 2011; Barnett, 2010). Evaluations of the Head Start program in the United States reveal that cognitive and behavioral gains are disproportionately concentrated among the lowest-performing children, implying an equalizing effect of preschool education (Bitler et al., 2014). In contrast, the complementarity hypothesis posits that children with higher initial skills or those in more supportive environments benefit more, consistent with the theory of dynamic complementarity (Cunha and Heckman, 2007). Results from the Tennessee STAR experiment indicate that interventions improving learning conditions often yield the greatest gains among the highest-performing students (Krueger, 1999; Chetty et al., 2011).

Hanushek (1999), for example, points out that the score gains associated with the treatment group in the STAR project were observed only in the early years, and argued that if these gains were driven by effects on class size, they should have observed a widening score gap as the treatment and control groups progressed through the experiment. Some studies (Bitler et al., 2006; Heckman et al., 1997) suggest that such analyses may overlook certain important dimensions of heterogeneity: in particular, if the variation within the group in the effects of class size exceeds the variation across groups in the average impacts, then subgroup analyses may fail to capture important differences in treatment effects across the distribution of outcomes. This information may be crucial for making informed decisions regarding educational policies aimed at reducing inequalities. These distribution effects highlight the limitations of quantile-based analyses. Standard regression approaches may mask heterogeneity, whereas quantile-based treatment effect estimators reveal substantial variation across the entire performance spectrum (Bitler et al., 2006; Jackson and Page, 2013). Very few studies in Francophone Africa examine the distributional effects of preschool education on school performance. This research addresses this gap by applying a quantile-based framework to understand which children benefit most from preschool education in Togo across the performance distribution.

4 Methodology

4.1 Empirical Strategy

The various methods used to assess the impact of preschool education on primary school performance include propensity score matching (PSM) (Zhang, 2017; Belfield and Garcia, 2014), randomized controlled trials (RCTs) (Wong et al., 2013; Jensen et al., 2017), and instrumental variable (IV) approaches (Akabayashi et al., 2023; Berlinski et al., 2009). PSM relies on the assumption that selection into preschool is fully explained by observed characteristics — an assumption that may not hold in the presence of unobservable confounders, potentially biasing estimates in either direction. Randomized controlled trials provide good estimates but are costly. IV regression controls for endogeneity, which is important in studies of the impact of preschool

education on school performance (Jakiela et al., 2024; Akabayashi et al., 2023). However, previous studies show that IVs for preschool attendance can be difficult to defend theoretically and empirically, as they rely on assumptions which are often untestable. In addition, results are often not generalizable to other subgroups and may fail to identify heterogeneous effects (Heckman and Urzua, 2010; Angrist and Imbens, 1995; Angrist and Krueger, 1992). IV quantile regression is suitable but in absence of a credible enough instrumental variable, the study uses conditional quantile regression controlling for a large set of variables and stratum fixed-effects to try to minimize the endogeneity issue. Thus, this study uses conditional and unconditional quantile regression models (Firpo et al., 2009; Melly, 2005).

The differences in primary school learning outcomes among students depending on access to preschool education vary across the distribution of learning outcomes. Therefore, we regress primary school learning outcomes in Grades 2 and 6 on a dummy variable for access to preschool education and observed characteristics using conditional quantile regression (CQR). More specifically, we model the primary school learning outcomes in reading and mathematics R_i of student i as follows:

$$R_i = X_i\beta_\tau + u_{\tau i} \quad \text{with} \quad Q_\tau\left(R_i|X_i\right) = X_i\beta_\tau \tag{1}$$

Where X_i denotes the vector of explanatory variables, including the constant, and β_τ denotes the vector of corresponding coefficients. As explanatory variables, we use a dummy variable for access to preschool education as well as variables indicating the characteristics of students, households, schools, classes, and teachers. The function $Q_\tau\left(R_i|X_i\right)$ denotes the $\tau - th$ conditional quantile of student learning outcomes conditional on the explanatory variables and $u_{\tau i}$ is an error term with $Q_\tau\left(u_{\tau i}|X_i\right) = 0$ (Koenker, 2017; Koenker and Hallock, 2001). CQR allow us to assess the difference between students with and without access to preschool education along the distribution of learning outcomes among students with the same characteristics.

However, the non-linearity of the conditional quantile function means that the difference in primary school performance between students with and without access to preschool education at the $\tau - th$ conditional and unconditional quantile may differ. Firpo et al. (2009) propose using unconditional quantile regression (UQR) to obtain the best estimates of this difference along the distribution of primary school students' learning outcomes. The basic idea behind UQR is to model the Recentered Influence Function (RIF) of the $\tau - th$ unconditional quantile Q_τ of expected primary school learning outcomes R_i which can be expressed as follows:

$$RIF\left(R_i; Q_\tau\right) = Q_\tau + \frac{\tau - 1\left\{R_i \leq Q_\tau\right\}}{f_R(Q_\tau)} \tag{2}$$

Where $f_R(Q_\tau)$ represents the marginal density of R_i, and $\tau - 1\{R_i \leq Q_\tau\}$ is the indicator function (Firpo et al., 2009). Assuming that the conditional expectation function of the RIF of Q_τ is linear, we obtain a linear regression model:

$$RIF\left(R_i; Q_\tau\right) = X_i\gamma_\tau + \upsilon_{\tau i} \tag{3}$$

Where γ_τ denotes the coefficient vector and $\upsilon_{\tau i}$ denotes the error term with $E\left[\upsilon_{\tau i}|X\right] = 0$. Standard ordinary least squares (OLS) regression of equation (3) provides estimates of the UQR coefficients, which can be interpreted as partial effects on the unconditional quantiles of R_i.

To assess the extent to which the results of the conditional quantile regression may be plagued by endogeneity, we compare results of a stratum fixed-effects Ordinary Least Squares (OLS) estimation to that of propensity score estimators: Inverse Probability Weighting (IPW), Augmented Inverse Probability Weighting (AIPW), and Inverse-Probability-Weighted Regression Adjustment (IPWRA). The rationale of this comparison is that stability of the results of the stratum fixed-effects Ordinary Least Squares may reflect lesser endogeneity issue in the conditional quantile estimation with stratum fixed-effects.

Given the absence of a credible instrumental variable, all results in this study are interpreted as associations rather than causal effects. Although stratum fixed effects and multiple robustness tests help to account for observed confounding factors, unobserved selections such as differences in parental motivation or early stimulation at home cannot be ruled out (Cunningham, 2021).

Following the example of major surveys in the education sciences, the analysis of data from the PASEC2019 survey requires the estimation of standard errors using a replication-weight-based approach. These weights are provided in both databases — for Grade 2, 45 replication weights (rwgt0 to rwgt45) are available, while for Grade 6, there are 90 (rwgt0 to rwgt90). Furthermore, PASEC2019 is based on a three-stage cluster-stratified sampling design, designed to ensure the representativeness of estimates at the national level. In this study, sampling weights were systematically incorporated into the econometric estimates to ensure the absence of bias in the estimated parameters.

4.2 Data

This research draws on secondary data from CONFEMEN's Programme for the Analysis of Education Systems (PASEC)[5], whose 2019 edition is the second international comparative assessment of educational achievement in 14 French-speaking countries in sub-Saharan Africa. The assessment measured students' skills at the beginning and end of primary school, evaluated teachers' disciplinary and pedagogical knowledge, and collected contextual information from students, teachers, and school principals. Designed to improve the quality, efficiency, and eq-

[5] An initiative of the Conference of Francophone Ministers of Education (CONFEMEN).

uity of education systems, PASEC analyzes the main school and non-school factors influencing learning. Since its creation in 1991, it has conducted national assessments in more than 20 countries in Africa and Asia that share a French-speaking educational heritage. The 2019 edition remains the largest international assessment conducted in French-speaking Africa to date, including Togo, where a representative sample covered more than 8,000 students, 1,400 teachers, and 400 schools. In this study, we included 8,209 students, of whom 2,092 were in second grade (Grade 2) and 6,117 were in sixth grade (Grade 6). PASEC data offers a high level of comparability and standardization. PASEC data was collected based on a three-stage stratified simple random sampling design, which guarantees nationally representative samples for each country.

Schools were first selected using a systematic procedure. The strata were constructed from the country's official list of schools with students enrolled in the target classes. The following variables were used for stratification: regions or districts (varying from country to country), type of school, geographical location (urban/rural). Within each stratum, schools are sampled using systematic sampling with probability proportional to size. For example, per country, the standard sample size is 180 schools for the sixth grade. In the second stage, one classroom from the target grade was selected from the schools sampled using simple random sampling. In the third stage, 20 sixth graders were selected from each classroom sampled using simple random sampling. If a classroom had 20 students or fewer, all students were selected. The assessments carried out as part of the study tested students' numeracy and literacy skills using standardized procedures and instruments in the country's official language(s) of instruction. In the case of the data for second and sixth graders, which we will use in this research, "paper-and-pencil" tests were administered collectively in each classroom. The tests were carried out by external assessors to ensure objective scoring.

Test results are based on multiple-choice tests and are calculated using the plausible value methodology used by the International Association for the Evaluation of Educational Achievement and the Organization for Economic Co-operation and Development (OECD) for its Programme for International Student Assessment (PISA) tests. Mathematics and reading test results were standardized by PASEC to a mean of 500 and a standard deviation of 100. In addition, detailed information was collected on various student characteristics, including student gender, social status of students' parents, teachers, classes and access to preschool (nursery schools, preschools, etc.). Tests and questionnaires are standardized in all participating and/or selected countries, including Togo, to ensure maximum comparability. This database is suitable for this paper, as it contains information on the learning outcomes of students in reading and mathematics at primary school (Grades 2 and 6) who have access to preschool education, and of those who do not. It also contains information about control variables. Table 2 shows variable definitions/measurements and descriptive statistics.

An analysis of the data disaggregated by students' place of residence reveals a clear rural predominance in the sample. More specifically, 35.7% of Grade 2 students live in urban areas, compared with 64.3% in rural areas; a similar distribution is observed in Grade 6, where 33.7% of students live in urban areas compared to 66.3% in rural areas. This persistent spatial imbalance is consistent with Togo's overall demographic structure and has important implications for analyzing the link between preschool education and subsequent school performance at the primary level.

Table 1: Descriptive statistics of variables for students in Grades 2 and 6

	Grade 2				Grade 6			
	Mean	**Std. dev.**	**Min**	**Max**	**Mean**	**Std. dev.**	**Min**	**Max**
Variable of interest								
Access to preschool (1 = yes; 0 = no)	0.419	0.493	0	1	0.353	0.478	0	1
Learning outcomes								
Reading scores	470.884	107.246	139.645	863.648	488.804	103.489	181.595	819.740
Mathematics scores	485.668	91.672	194.190	762.799	489.391	103.207	147.919	865.996
Student characteristics								
Student's age (years)	7.446	1.117	4	14	12.345	1.555	8	20
Student boys (1 = yes; 0 = no)	0.530	0.499	0	1	0.505	0.500	0	1
Urban (1 = yes; 0 = no)	0.357	0.479	0	1	0.337	0.473	0	1
School characteristics								
Electricity at school (1 = yes; 0 = no)	0.520	0.500	0	1	0.539	0.499	0	1
Public school (1 = yes; 0 = no)	0.711	0.453	0	1	0.712	0.453	0	1
School canteen (1 = yes; 0 = no)	0.079	0.270	0	1	0.059	0.236	0	1
Free public school (1 = yes; 0 = no)	0.331	0.471	0	1	0.318	0.466	0	1
Infrastructure index	46.353	9.226	31.308	72.887	46.068	8.943	31.146	71.674
School size	5.561	1.708	3	13	5.606	1.633	3	14
Class characteristics								
Class size	44.116	18.522	14	112	34.382	10.366	11	62
Class equipment index	47.405	8.341	30.889	101.263	54.834	10.763	34.017	101.404
Teacher characteristics								
Teacher's age (years)	38.787	8.675	23	59	41.921	6.940	23	59
Male teacher (1 = yes; 0 = no)	0.655	0.476	0	1	0.859	0.348	0	1

Notes: No variables have missing observations; N = 2,092 for Grade 2 and N = 6,117 for Grade 6 for all variables. Scores in reading and mathematics are measured in relation to the international average = 500 and SD = 100. School infrastructure and classroom equipment indices are also measured in relation to the international average = 50 and SD = 10. SD=Standard Deviation.

5 Results and Discussion

This section presents results from the Unconditional, Conditional, and Stratum Fixed-Effects Conditional quantile regressions. We begin with Grade 2 before turning to Grade 6, considering students' performance scores in reading and mathematics. With that in mind, we will tackle each of the following in turn: Associated distributional effects of preschool education on primary outcomes, Heterogeneous Effects of Student, Household, School, Class, Teachers, and Additional Results by Student Area of Residence.

5.1 Examining the Distributional Relationship between Preschool Education and Primary Students' Learning Outcomes

This study examines the association between access to preschool education and learning outcomes in Grade 2 and Grade 6 of primary school, considering variations in student performance across different distribution levels of reading and mathematics scores. It thus highlights the heterogeneity of the associations of preschool education depending on student profiles. In fact, the joint Wald test leads to the rejection of the null hypothesis that the coefficients are equal across the different quantiles – $H_0 : (10th) = (50th) = (90th)$, thereby highlighting a statistically significant heterogeneity in the determinants of student performance across the distribution (Bitler et al., 2006). The corresponding χ^2 values and associated probabilities are presented in Tables 2, 3, 4, 5 and 6. Furthermore, the analysis of results obtained from unconditional, conditional, and conditional quantile regressions with fixed effects provides a better understanding of the nuances of these approaches and allows for a more refined assessment of the extent of the results according to the approaches adopted (Firpo et al., 2009).

The results of unconditional quantile regressions (Table 2) show that access to preschool education has an overall positive association on school performance. In Grade 2, for reading, this access is associated with an improvement in scores of 0.213 SD at the 10th quantile, 0.171 SD at the median, and 0.237 SD at the 90th quantile. In mathematics, a significant association is also observed at the 10th quantile, with a performance score of 0.185 SD. In Grade 6, the positive associations are confirmed, although they are more pronounced in higher quantiles. In reading, the score gains associated with access to preschool education are 0.156 SD at the 50th quantile and 0.292 SD at the 90th quantile. In mathematics, these associated score gains are 0.109 SD at the median and 0.193 SD at the 90th quantile. Furthermore, the results of conditional quantile regressions (Table 3) show the same trends as the results of unconditional quantile regressions. We continue the analysis by considering the results of conditional quantile regressions with fixed effects (Table 4). This technique captures the entire distribution, controls unobserved heterogeneity, and minimizes endogeneity bias by providing more precise estimates (Galvao Jr, 2011).

Table 2: Estimating the Influence of Preschool Education on Learning Outcomes—UQR

	Grade 2						Grade 6					
	Reading/100			**Mathematics/100**			**Reading/100**			**Mathematics/100**		
Variable of interest	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**
Access to preschool	**0.213*** **	**0.171*** **	**0.237***	**0.185*** **	**0.090**	**0.059**	**0.008**	**0.156*** **	**0.292*** **	**0.004**	**0.109*** **	**0.193*** **
	(0.065)	**(0.050)**	**(0.127)**	**(0.049)**	**(0.057)**	**(0.088)**	**(0.032)**	**(0.040)**	**(0.047)**	**(0.025)**	**(0.035)**	**(0.064)**
Student characteristics												
Student's age	0.067*	0.043*	0.037	0.043	0.058**	0.081***	-0.006	-0.062***	-0.106***	-0.013	-0.032***	-0.069***
	(0.035)	(0.024)	(0.051)	(0.030)	(0.025)	(0.031)	(0.008)	(0.012)	(0.016)	(0.009)	(0.010)	(0.016)
Student boys	0.086	0.041	0.038	0.088*	0.046	-0.011	0.018	0.037	0.080*	0.077***	0.105***	0.110**
	(0.064)	(0.043)	(0.123)	(0.047)	(0.048)	(0.068)	(0.027)	(0.036)	(0.047)	(0.028)	(0.030)	(0.047)
School characteristics												
Electricity at school	0.262***	0.354***	0.196**	0.223***	0.257***	0.064	0.155***	0.470***	0.327***	0.179***	0.407***	0.388***
	(0.084)	(0.065)	(0.092)	(0.064)	(0.069)	(0.069)	(0.033)	(0.046)	(0.037)	(0.036)	(0.033)	(0.045)
Public school	0.138	0.098	-0.666**	-0.051	-0.057	-0.391*	-0.290***	-0.687***	-0.381***	-0.192***	-0.516***	0.033
	(0.164)	(0.119)	(0.266)	(0.149)	(0.135)	(0.213)	(0.078)	(0.085)	(0.098)	(0.060)	(0.090)	(0.104)
School canteen	-0.010	-0.053	0.574***	0.118	0.144	0.228*	-0.092	0.094	0.015	0.040	0.102	-0.055
	(0.137)	(0.096)	(0.195)	(0.111)	(0.108)	(0.121)	(0.074)	(0.082)	(0.068)	(0.063)	(0.070)	(0.086)
Free public school	0.303*	0.519***	0.005	0.213	0.355***	0.062	0.008	-0.115	0.004	0.047	-0.014	0.141*
	(0.157)	(0.111)	(0.235)	(0.140)	(0.122)	(0.216)	(0.074)	(0.072)	(0.084)	(0.063)	(0.085)	(0.082)
Infrastructure index	0.011***	0.008**	0.051***	0.007**	0.012***	0.017***	0.000	0.021***	0.047***	0.002	0.017***	0.043***
	(0.003)	(0.003)	(0.010)	(0.004)	(0.003)	(0.005)	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.003)
School size	0.071***	0.075***	0.187***	0.039***	0.097***	0.118***	0.037***	0.122***	0.060***	0.054***	0.149***	0.075***
	(0.016)	(0.017)	(0.043)	(0.013)	(0.017)	(0.032)	(0.006)	(0.010)	(0.018)	(0.007)	(0.009)	(0.019)
Class characteristics												
Class size	-0.001	-0.001	-0.006***	0.002	-0.003**	-0.005***	-0.002	-0.008***	-0.004***	-0.006***	-0.009***	-0.005**
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
Class equipment index	0.010***	0.021***	0.021**	0.007***	0.014***	0.003	0.001	0.005***	0.024***	0.002**	0.010***	0.038***
	(0.003)	(0.003)	(0.010)	(0.002)	(0.003)	(0.005)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)	(0.004)
Teacher characteristics												
Teacher's age	0.009**	0.003	0.002	0.006*	0.007**	0.011***	-0.000	-0.001	0.006*	0.000	0.005**	0.016***
	(0.004)	(0.003)	(0.007)	(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)
Male teacher	-0.002	-0.070	-0.040	0.045	-0.053	-0.171*	-0.030	0.090*	-0.100	0.037	0.057	0.109
	(0.058)	(0.053)	(0.126)	(0.066)	(0.056)	(0.091)	(0.044)	(0.046)	(0.066)	(0.046)	(0.047)	(0.074)
Constant	0.845	1.950***	1.813**	1.870***	2.230***	4.010***	3.727***	3.945***	3.771***	3.503***	3.067***	1.717***
	(0.540)	(0.331)	(0.870)	(0.380)	(0.422)	(0.501)	(0.182)	(0.241)	(0.344)	(0.176)	(0.237)	(0.430)
R^2	**0.071**	**0.186**	**0.137**	**0.063**	**0.133**	**0.069**	**0.037**	**0.234**	**0.208**	**0.045**	**0.231**	**0.167**
QH (Wald test)		**$_2$= 123.800**			**$_2$= 107.240**			**$_2$= 468.090**			**$_2$= 407.640**	
Prob (^{2})		**0.000**			**0.000**			**0.000**			**0.000**	
N		**2,092**			**2,092**			**6,117**			**6,117**	

*Notes: Bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1). QH= Quantile Heterogeneity.*

Table 3: Estimating the Influence of Preschool Education on Learning Outcomes—CQR

	Grade 2						Grade 6					
	Reading/100			**Mathematics/100**			**Reading/100**			**Mathematics/100**		
Variable of interest	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**
Access to preschool	**0.182*** **	**0.111** **	**0.187***	**0.126*** **	**0.056**	**0.120**	**0.079** **	**0.119*** **	**0.114*** **	**0.045**	**0.112*** **	**0.110** **
	(0.058)	**(0.053)**	**(0.098)**	**(0.043)**	**(0.053)**	**(0.091)**	**(0.033)**	**(0.030)**	**(0.040)**	**(0.031)**	**(0.030)**	**(0.049)**
Student characteristics												
Student's age	0.067**	0.027	0.046	0.071***	0.066***	0.070*	-0.041***	-0.063***	-0.082***	-0.031***	-0.030***	-0.046***
	(0.026)	(0.029)	(0.050)	(0.020)	(0.021)	(0.040)	(0.011)	(0.009)	(0.018)	(0.009)	(0.006)	(0.014)
Student boys	0.053	0.041	0.035	0.082	0.039	0.018	0.045*	0.037	0.073*	0.072**	0.087***	0.104***
	(0.058)	(0.056)	(0.106)	(0.064)	(0.045)	(0.074)	(0.026)	(0.031)	(0.041)	(0.028)	(0.030)	(0.040)
School characteristics												
Electricity at school	0.216***	0.261***	0.430***	0.099	0.230***	0.172	0.185***	0.394***	0.439***	0.196***	0.335***	0.511***
	(0.066)	(0.055)	(0.113)	(0.074)	(0.057)	(0.108)	(0.030)	(0.037)	(0.055)	(0.030)	(0.039)	(0.045)
Public school	-0.300**	-0.001	-0.289*	-0.300	-0.177	0.045	-0.416***	-0.418***	-0.543***	-0.429***	-0.420***	-0.080
	(0.140)	(0.114)	(0.174)	(0.193)	(0.142)	(0.144)	(0.054)	(0.046)	(0.098)	(0.061)	(0.071)	(0.095)
School canteen	-0.023	0.006	0.645	0.130	0.196**	0.378***	-0.104***	-0.006	0.055	0.038	0.129**	0.000
	(0.129)	(0.083)	(0.421)	(0.103)	(0.090)	(0.123)	(0.039)	(0.074)	(0.063)	(0.048)	(0.058)	(0.118)
Free public school	0.057	0.374***	0.494***	0.117	0.150	0.427***	0.074	0.027	-0.318***	0.090*	0.001	-0.065
	(0.142)	(0.103)	(0.139)	(0.147)	(0.113)	(0.132)	(0.054)	(0.042)	(0.085)	(0.047)	(0.070)	(0.082)
Infrastructure index	0.017***	0.020***	0.013**	0.020***	0.015***	0.007*	0.012***	0.021***	0.026***	0.013***	0.019***	0.025***
	(0.003)	(0.002)	(0.007)	(0.003)	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
School size	0.062**	0.107***	0.130***	0.043*	0.095***	0.092***	0.077***	0.092***	0.093***	0.091***	0.104***	0.100***
	(0.027)	(0.017)	(0.019)	(0.023)	(0.019)	(0.025)	(0.011)	(0.011)	(0.014)	(0.010)	(0.008)	(0.017)
Class characteristics												
Class size	0.000	-0.000	-0.003*	0.001	-0.002	-0.006***	-0.003**	-0.005***	-0.008***	-0.005***	-0.006***	-0.012***
	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)
Class equipment index	0.012***	0.016***	0.034***	0.005	0.008***	0.014**	0.007***	0.013***	0.011***	0.009***	0.014***	0.026***
	(0.003)	(0.003)	(0.012)	(0.004)	(0.003)	(0.007)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Teacher characteristics												
Teacher's age	0.001	0.003	0.009	0.006**	0.008***	0.013***	-0.001	0.000	0.003	0.001	0.005**	0.014***
	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)	(0.005)	(0.002)	(0.001)	(0.004)	(0.003)	(0.002)	(0.004)
Male teacher	0.029	-0.041	-0.220**	0.096	0.015	-0.162**	-0.048	0.019	-0.104*	-0.030	0.041	0.022
	(0.071)	(0.074)	(0.110)	(0.062)	(0.042)	(0.081)	(0.039)	(0.043)	(0.054)	(0.033)	(0.043)	(0.083)
Constant	1.386***	1.760***	2.230***	1.550***	2.330***	3.427***	3.294***	3.579***	5.120***	2.909***	2.996***	2.979***
	(0.353)	(0.387)	(0.846)	(0.376)	(0.361)	(0.571)	(0.278)	(0.171)	(0.247)	(0.152)	(0.222)	(0.352)
Pseudo R^2	**0.127**	**0.146**	**0.196**	**0.104**	**0.114**	**0.104**	**0.096**	**0.207**	**0.231**	**0.115**	**0.189**	**0.210**
QH (Wald test)		**^{2}= 45.530**			**^{2}= 26.800**			**^{2}= 317.910**			**^{2}= 296.970**	
Prob (^{2})		**0.000**			**0.000**			**0.000**			**0.000**	
N		**2,092**			**2,092**			**6,117**			**6,117**	

*Notes: Bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1). QH= Quantile Heterogeneity.*

Table 4: Estimating the Influence of Preschool Education on Learning Outcomes—CQR with stratum fixed-effects

	Grade 2						Grade 6					
	Reading/100			**Mathematics/100**			**Reading/100**			**Mathematics/100**		
Variable of interest	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**
Access to preschool	**0.233*** **	**0.178*** **	**0.268*** **	**0.154*** **	**0.134*** **	**0.173*** **	**0.052***	**0.136*** **	**0.199*** **	**0.007**	**0.135*** **	**0.136*** **
	(0.062)	**(0.048)**	**(0.102)**	**(0.052)**	**(0.044)**	**(0.075)**	**(0.031)**	**(0.032)**	**(0.052)**	**(0.040)**	**(0.023)**	**(0.035)**
Student characteristics												
Student's age	0.050**	0.009	0.021	0.054**	0.031	0.019	-0.056***	-0.078***	-0.105***	-0.052***	-0.061***	-0.080***
	(0.022)	(0.029)	(0.036)	(0.021)	(0.021)	(0.033)	(0.007)	(0.008)	(0.011)	(0.009)	(0.009)	(0.015)
Student boys	0.081	-0.003	0.061	0.107**	0.055	0.072	0.010	0.046**	0.046	0.094***	0.093***	0.164***
	(0.079)	(0.049)	(0.092)	(0.042)	(0.040)	(0.066)	(0.032)	(0.019)	(0.041)	(0.022)	(0.024)	(0.043)
School characteristics												
Electricity at school	0.252***	0.153**	0.088	0.068	0.091*	0.049	0.132***	0.219***	0.355***	0.157***	0.229***	0.266***
	(0.095)	(0.060)	(0.138)	(0.067)	(0.055)	(0.095)	(0.024)	(0.026)	(0.032)	(0.034)	(0.027)	(0.040)
Public school	-0.110	0.034	-0.038	-0.154	-0.157	-0.031	-0.224***	-0.142**	-0.244***	-0.149***	-0.092**	-0.011
	(0.223)	(0.104)	(0.120)	(0.144)	(0.172)	(0.133)	(0.066)	(0.058)	(0.071)	(0.051)	(0.036)	(0.114)
School canteen	0.039	-0.017	0.380**	0.231**	0.213***	0.252**	0.044	-0.113**	0.026	-0.015	0.010	-0.091
	(0.138)	(0.087)	(0.180)	(0.091)	(0.058)	(0.103)	(0.058)	(0.048)	(0.091)	(0.046)	(0.056)	(0.093)
Free public school	0.105	0.284**	0.250*	0.185	0.112	0.100	-0.001	0.016	-0.253***	0.001	-0.006	-0.089
	(0.247)	(0.117)	(0.139)	(0.125)	(0.161)	(0.153)	(0.045)	(0.053)	(0.060)	(0.047)	(0.030)	(0.094)
Infrastructure index	0.012**	0.012***	0.009	0.021***	0.015***	0.001	0.001	0.009***	0.013***	0.003	0.009***	0.015***
	(0.005)	(0.003)	(0.006)	(0.004)	(0.003)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
School size	0.059*	0.101***	0.149***	0.039*	0.086***	0.084***	0.034***	0.065***	0.072***	0.072***	0.080***	0.093***
	(0.031)	(0.017)	(0.030)	(0.024)	(0.015)	(0.022)	(0.013)	(0.010)	(0.007)	(0.012)	(0.007)	(0.017)
Class characteristics												
Class size	-0.003	-0.001	-0.004*	0.003*	-0.001	-0.006**	-0.008***	-0.010***	-0.012***	-0.009***	-0.009***	-0.017***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Class equipment index	0.012***	0.013***	0.012*	0.004	0.005*	0.006	0.003*	0.004***	0.007***	0.003**	0.008***	0.016***
	(0.004)	(0.003)	(0.007)	(0.003)	(0.003)	(0.005)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Teacher characteristics												
Teacher's age	0.009**	0.008***	0.011**	0.005**	0.008***	0.013***	0.003	3.54e-05	0.001	0.003**	0.005***	0.010***
	(0.004)	(0.003)	(0.005)	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.003)	(0.001)	(0.002)	(0.003)
Male teacher	-0.034	-0.071	-0.158*	0.105	-0.002	-0.178*	-0.086**	0.032	0.026	-0.100***	0.049	0.140**
	(0.089)	(0.047)	(0.087)	(0.074)	(0.056)	(0.097)	(0.040)	(0.033)	(0.053)	(0.025)	(0.031)	(0.063)
Constant	1.290***	2.130***	3.414***	1.583***	2.726***	4.721***	4.396***	4.736***	5.950***	3.778***	3.817***	4.181***
	(0.403)	(0.340)	(0.485)	(0.363)	(0.322)	(0.478)	(0.206)	(0.101)	(0.172)	(0.154)	(0.178)	(0.348)
FE: Stratum-Golfe Lomé	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Kara	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Maritime	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Plateaux	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Savanes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	**0.136**	**0.173**	**0.255**	**0.115**	**0.137**	**0.154**	**0.193**	**0.295**	**0.301**	**0.199**	**0.272**	**0.298**
QH (Wald test)		**^{2}= 79.590**			**^{2}= 8.720**			**^{2}= 100.350**			**^{2}= 63.270**	
Prob (^{2})		**0.000**			**0.000**			**0.000**			**0.000**	
N		**2,092**			**2,092**			**6,117**			**6,117**	

*Notes: Bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1). QH= Quantile Heterogeneity.*

The results are consistent. In other words, access to preschool education has a positive and significant association on school performance in primary school, particularly in second grade. In reading, preschool education is associated with improved school performance by 0.233 SD at the 10th quantile. In other words, a gain of 0.233 SD at the 10th quantile in Grade 2 reading is comparable to roughly half the effect size reported by Berlinski et al. (2009) for Argentina. Also, 0.178 SD at the 50th quantile, and 0.268 SD at the 90th quantile. In mathematics, preschool attendance is associated with score gains of 0.154 SD at the 10th quantile, 0.134 SD at the median, and 0.173 SD at the 90th quantile. Figure 3 illustrates the subtleties of these results. In Grade 6, the associations remain positive and significant, although they are more pronounced at the 90th quantile. In reading, access to preschool education is associated with score gains of 0.052 SD at the 10th quantile, 0.136 SD at the 50th quantile and 0.199 SD at the 90th quantile. These score gains in mathematics are 0.135 SD at the median and 0.136 SD at the 90th quantile. Figure 4 also illustrates the subtle graphic nuances of these results. These results confirm the central hypothesis of this study: access to preschool education has differentiated associations depending on students' performance levels, with particularly significant gains at the upper and lower ends of the distribution. This heterogeneity of association effects, in both Grade 2 and Grade 6, underscores the importance of a targeted approach in Togo's education policy.

In other words, these findings show that preschool education plays a role both in helping lower-performing students catch up and in enhancing the skills of higher-performing students. These findings confirm the work of Nores and Barnett (2010) and Engle et al. (2011), which show that preschool education is significantly associated with improved school performance, particularly in low-income countries. Indeed, the associations are most pronounced in the 90th quantile in Grade 2, indicating that the highest-performing children benefit most from preschool, particularly in reading, which corroborates Heckman's (2006) conclusions that early investments in human capital are most effective when they target children starting primary school. Regarding math performance scores, a similar pattern is observed, although the associations are concentrated at the lower and upper ends of the distribution. These findings are consistent with those of Gormley et al. (2005) and Yoshikawa et al. (2013), who demonstrated that high-quality preschool programs have measurable positive associations, particularly for children from disadvantaged backgrounds. This study highlights that the effect of preschool is not limited to an average improvement but extends across the entire distribution of outcomes, making it a strategic lever for reducing educational inequalities.

In Grade 6, the results show that access to preschool education continues to have measurable positive associations on students' school performance even several years later. In reading, these associations are concentrated in the middle and upper parts of the distribution, suggesting that preschool enhances the achievement of average and high-performing students. This differentiated progression supports the idea that preschool education promotes long-term skill

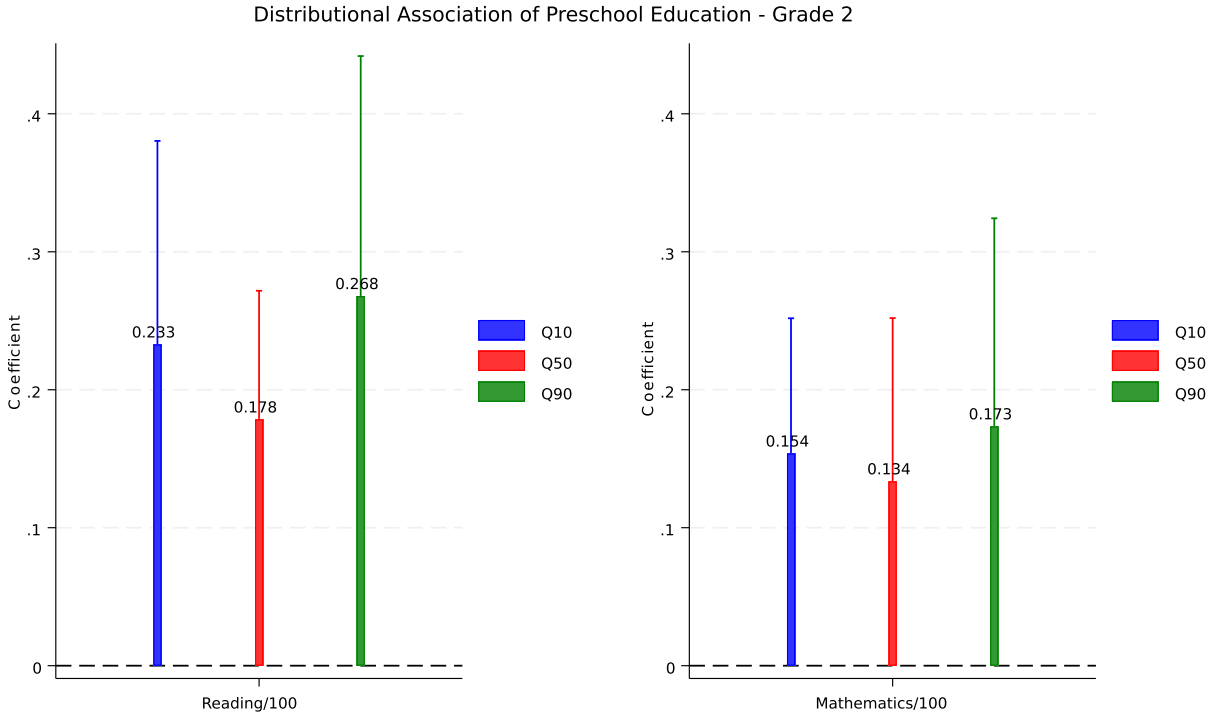
accumulation and serves as a springboard for educational success, as argued by Barnett (1995) and Yoshikawa et al. (2013). The pronounced association at the 90th quantile may also indicate that high-performing students are better able to capitalize on the cognitive foundations in reading established in preschool, thereby reinforcing the dynamics of cumulative learning (Cunha and Heckman, 2007). In mathematics, the association of preschool becomes significant at the 50th quantile and intensifies at the 90th quantile. This suggests that preschool education exerts a differentiated influence on mathematical performance, benefiting students in the middle and upper ranges of distribution. This finding is consistent with the analyses by Gormley et al. (2005) and Duncan et al. (2007), according to which the associations of preschool programs on mathematical skills may emerge later and be more pronounced among children who already have a solid cognitive foundation. These results are consistent with preschool education serving as a potential lever not only for strengthening basic skills but also for supporting school excellence throughout primary school (Jakiela et al., 2024; Wang et al., 2023).

Additionally, this paper finds persistence through Grade 6 in Togo. However, Jakiela et al. (2024) find no persistence in rural Kenya beyond age 4. More importantly, Blanden et al. (2022) show that the positive effect of preschool education on school performance fades by age 7 in England. In the context of Togo, this result can be explained essentially by the high concentration of preschool schools in urban areas, which tends to lead to educational trajectories in better-resourced environments; disparities in quality among primary schools reinforce these gains; and the composition of the sample amplifies this effect over time. Also, this result can be explained by the model of dynamic skill formation and cumulative effects (Cunha and Heckman, 2007). Preschool education contributes to the development of fundamental cognitive and socio-emotional skills, such as language, memory, and self-regulation, that enhance children's ability to benefit from their subsequent schooling. As Heckman (2006) points out, early investments increase the productivity of subsequent learning, thereby generating self-reinforcing learning trajectories over time (Heckman, 2006; Cunha and Heckman, 2007). Empirical data from low- and middle-income countries confirm this mechanism (Bietenbeck et al., 2017; McCoy et al., 2017). To this end, these studies document positive and lasting associations between preschool attendance and later outcomes in reading, writing, and mathematics, while Engle et al. (2011) and Rao et al. (2014) highlight the role of early learning in long-term school success. These findings suggest that the benefits gained in early childhood through preschool education are not merely temporary but can endure when continuously reinforced within the school system.

The greater persistence observed at the median and upper quantiles in Grade 6 highlights the importance of complementarities and unequal learning environments. Students in these segments of the distribution are more likely to benefit from higher-quality instruction and a supportive family environment, which amplifies the benefits of preschool education (Cunha et al., 2010). In contrast, experimental studies, such as that by Bouguen et al. (2018), show that when

the quality of preschool education is low or subsequent educational environments are unstimulating, initial gains may diminish or fail to translate into long-term success. This suggests that persistence in the top quantiles reflects not only initial exposure to preschool education but also the continuity between early skills and subsequent learning opportunities. Broadly speaking, these results teach us that while preschool education is positively associated with subsequent performance on average, this lasting association varies by income level, underscoring the importance of quality and continuity in educational systems in low-income contexts.

Figure 3: Distributional relationship between preschool education and learning outcomes in primary school in Grade 2

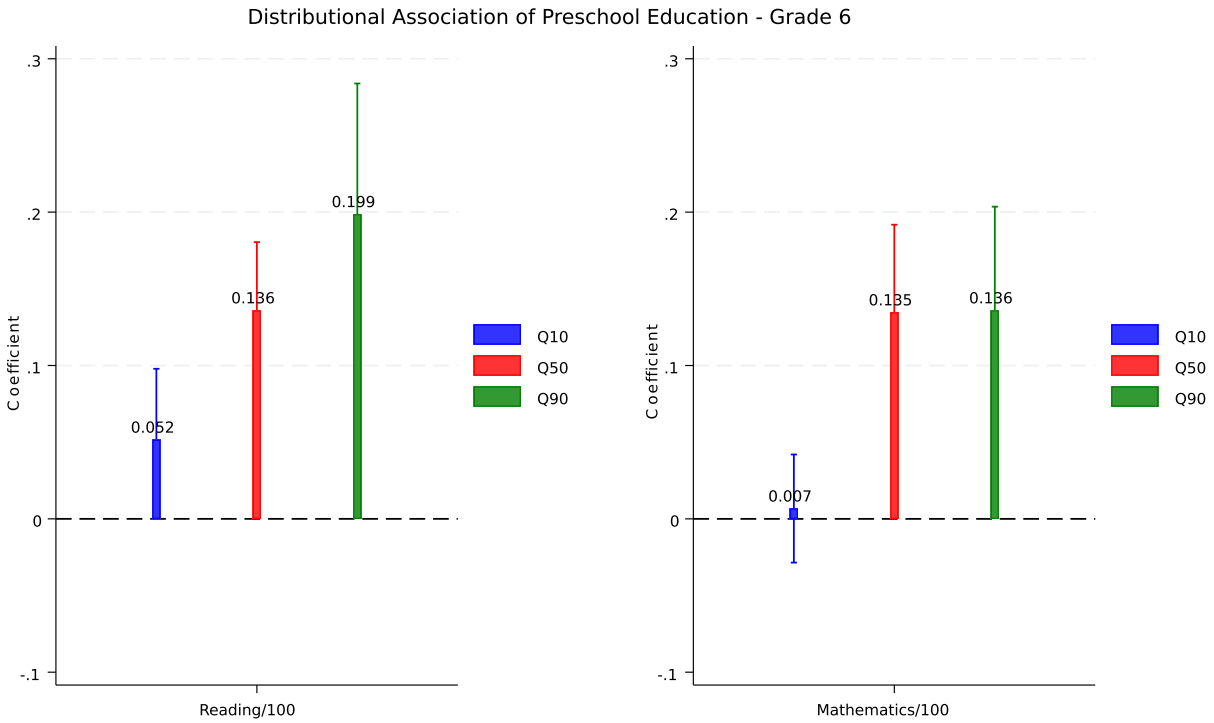


Notes: Source: Authors' estimates from conditional quantile regression with stratum fixed effects (see Table 4). Dots show the coefficient on Access to Preschool at each quantile; shaded area shows the 95% confidence interval. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1).

5.1 Heterogeneous Effects of Student, Household, School, Class, and Teacher Characteristics

A more detailed analysis of student characteristics reveals that age has a varying association on learning outcomes depending on grade level and subject. In Grade 2, increasing age is associated with improved performance in reading and mathematics at the 10th quantile. In Grade 6, however, the association of age becomes negative: increasing age corresponds to lower scores in reading and mathematics, particularly at the 10th, 50th, and 90th quantiles. Furthermore, boys appear to perform better than girls, but this gender difference varies by subject and grade

Figure 4: Distributional relationship between preschool education and learning outcomes in primary school in Grade 6



Notes: Source: Authors' estimates from conditional quantile regression with stratum fixed effects (see Table 4). Dots show the coefficient on Access to Preschool at each quantile; shaded area shows the 95% confidence interval. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1).

level. In Grade 2, boys perform better in mathematics at the 10th quantile. In Grade 6, they perform better in reading at the 50th quantile, as well as in mathematics at the 10th, 50th, and 90th quantiles. In Grade 2, age appears to play a protective or maturational role, particularly for lower-performing students, which could be explained by more advanced cognitive development or better socio-emotional readiness (Malmberg et al., 2012). However, the persistent negative association across quantiles in both subjects in Grade 6 suggests that age disrupts school trajectories, as demonstrated by Glewwe et al. (2001). Similarly, differences between girls and boys appear nuanced: boys tend to outperform girls in mathematics at the 10th quantile in Grade 2, and at a more advanced stage, in reading at the 50th quantile in Grade 6. This heterogeneity across subjects and quantiles reminds us that gender dynamics in learning are not uniform and depend on the school and social context, as explained in Fryer and Levitt (2010).

Furthermore, an analysis of school characteristics reveals that, in Grade 2, the availability of electricity at school is associated with improved student performance in reading at the 10th and 50th quantiles, and at the 50th quantile in mathematics. In other words, the availability of electricity at school has a more generalized positive association, contributing to better reading scores in Grade 2. We learn from this result that access to electricity at school positively influences students' school performance, but in different ways depending on grade level and performance

ranking. The association is concentrated among the lowest-performing and middle-performing students, which can be explained by better study conditions at school, such as lighting that allows them to do their homework in the evening (UNESCO, 2014). More importantly, in Grade 6, this availability of electricity at school benefits all students, including the highest-performing ones, suggesting that electricity becomes a more fundamental driver of school success, facilitating not only studying but also access to educational tools (radio, educational television, digital media), as highlighted by Banerjee and Duflo (2011) and Barron et al. (2020). This finding draws policymakers' attention to the link between basic infrastructure and learning inequalities in low-income countries such as Togo.

In addition, students of private schools tend to have higher scores than those attending public schools. In Grade 6, the negative association extends to the 10th, 50th, and 90th quantiles in reading, as well as the 10th and 50th quantiles in mathematics. This may reflect quality deficits linked to overcrowded classrooms, a lack of equipment, or less rigorous pedagogical supervision in public schools compared to private schools (Glewwe and Muralidharan, 2016). Furthermore, the presence of school canteens, established by the Togolese Government, contributes to an association of improved outcomes in Grade 2: a positive association is observed at the 90th quantile in reading and at the 10th, 50th, and 90th quantiles in mathematics. In Grade 6, a negative association is observed at the 50th quantile in reading. In this regard, school canteens are associated with an improvement in learning outcomes, particularly among students with intermediate or high performance, which corroborates the work of Aurino et al. (2023), who show that school meals promote concentration and school retention. Established in 2008, free public primary education in Togo reduces financial burdens on households and is associated with improvements reading performance in Grade 2, particularly at the 50th and 90th quantiles, suggesting positive associations that go beyond mere access to school. However, the negative association observed between preschool attendance and scores at the 90th quantile in Grade 6 may reflect disparities in quality and a lack of educational continuity, indicating that early learning gains are not always consolidated throughout the school trajectory.

Finally, the school infrastructure index and school size have a positive association in Grade 2 on performance in both subjects at all levels. In Grade 6, although school size continues to have a beneficial association on reading and mathematics scores, the infrastructure index remains significant for the 50th and 90th quantiles in reading and across all three quantiles in mathematics. In this regard, the positive associations of school size and infrastructure underscores the importance of the physical learning environment, consistent with the findings of Duflo et al. (2015) on the association of school infrastructure on school performance.

Classroom and teacher characteristics exhibit heterogeneous associations across grades, subjects, and performance levels. Regarding class characteristics, larger class sizes are associated with mixed outcomes in Grade 2, showing a negative association at the top quantile but a pos-

itive association in mathematics at the bottom quantile, suggesting that in early grades, larger classes do not necessarily hinder basic learning and may even support group dynamics (Banerjee et al., 2017). However, in Grade 6, class size consistently exerts a positive association across all quantiles and subjects, likely reflecting increased classroom management challenges at higher levels. On the other hand, the classroom equipment index shows a stable and positive association, particularly in reading in Grade 2 (at the 10th and 50th quantiles) and across all quantiles and subjects in Grade 6, highlighting the importance of adequate learning materials in improving student outcomes (Glewwe and Kremer, 2006). Concerning teacher characteristics, teacher age generally has a positive association on performance, especially in Grade 2 across all quantiles and subjects, and in Grade 6 in mathematics across all quantiles, suggesting that experience enhances teaching effectiveness, albeit unevenly. Teacher gender displays mixed associations: male teachers are associated with lower performance in Grade 2 at higher quantiles but show a positive association in Grade 6 mathematics at the top quantile, while negative associations persist at the lower quantile (Early et al., 2007). Overall, these findings indicate that both classroom environment and teacher attributes matter for student achievement, though their associations vary significantly depending on context and student performance distribution (Rockoff, 2004; Rivkin et al., 2005).

5.2 Additional Results: Considering the Student's Area of Residence

Access to quality educational services often varies considerably between urban and rural areas, reflecting disparities in school infrastructure, the availability of qualified teachers, and broader socioeconomic conditions (Jakiela et al., 2024; Wang et al., 2023; Blimpo et al., 2022). In this regard, examining the association between preschool education and outcomes by place of residence is an important heterogeneity analysis. This analysis is consistent with research highlighting that the outcomes of preschool education can vary across contexts characterized by resource constraints and different learning environments (Heckman, 2006; Engle et al., 2011; Duncan and Magnuson, 2013). The results presented in Table 5 show that in Grade 2, preschool attendance is associated with reading score gains of 0.246 SD at the 50th quantile and 0.248 SD at the 90th quantile in urban areas. On the other hand, a significant positive association is observed in rural areas at the 90th quantile. In mathematics, no significant association is detected in urban areas. However, in rural areas, preschool attendance is associated with an improvement in mathematics scores of 0.281 SD at the 90th quantile, suggesting that preschool education may compensate for the difficulties experienced by some groups of students from disadvantaged backgrounds.

At Grade 6 (Table 6), the positive associations observed in reading persist in urban settings, at both the median and upper levels. Furthermore, unlike the results obtained at Grade 2, positive associations also appear in rural settings, where preschool attendance is associated with an improvement in reading scores of 0.055 SD at the 50th quantile and 0.156 SD at the 90th

quantile. Similarly, in mathematics, positive associations appear in urban settings at Grade 6, with estimated gains of 0.063 SD at the 10th quantile, 0.102 SD at the 50th quantile and 0.191 SD at the 90th quantile, while no significant association was observed at Grade 2. Overall, these results suggest that the benefits of preschool education can vary across geographical contexts and manifest gradually throughout schooling (Jakiela et al., 2024). This trend is consistent with previous literature on early childhood development, which indicates that the benefits of early educational investments can unfold over time and become more visible at later stages of schooling (Yoshikawa et al., 2013).

Table 5: Estimating the Influence of Preschool Education on Learning Outcomes—CQR with stratum fixed-effects, Grade 2

	Reading/100						Mathematics/100					
	Urban			**Rural**			**Urban**			**Rural**		
	10th	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**
Variable of interest												
Access to preschool	**0.032**	**0.246****	**0.248****	**0.176**	**0.083**	**0.152***	**0.017**	**0.067**	**0.054**	**0.135**	**0.098**	**0.281*****
	(0.094)	**(0.097)**	**(0.107)**	**(0.112)**	**(0.057)**	**(0.085)**	**(0.084)**	**(0.117)**	**(0.147)**	**(0.084)**	**(0.068)**	**(0.077)**
Student characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Class characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	6.021***	4.376***	5.904***	-1.276*	-0.132	0.241	4.102***	4.828***	6.261***	0.830	1.083**	3.373***
	(0.460)	(0.855)	(1.143)	(0.760)	(0.446)	(0.514)	(0.484)	(0.807)	(0.736)	(0.556)	(0.435)	(0.549)
FE: Stratum-Golfe Lomé	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Kara	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Maritime	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Plateaux	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Savanes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	**0.148**	**0.110**	**0.230**	**0.144**	**0.177**	**0.275**	**0.129**	**0.078**	**0.083**	**0.115**	**0.143**	**0.219**
QH (Wald test)		**^{2}= 27.030**			**^{2}= 124.620**			**^{2}= 112.530**			**^{2}= 65.630**	
Prob (^{2})		**0.000**			**0.000**			**0.000**			**0.000**	
N		**748**			**1,344**			**748**			**1,344**	

*Notes: Bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1). QH= Quantile Heterogeneity.*

Table 6: Estimating the Influence of Preschool Education on Learning Outcomes—CQR with stratum fixed-effects, Grade 6

	Reading/100						Mathematics/100					
	Urban			**Rural**			**Urban**			**Rural**		
	10th	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**
Variable of interest												
Access to preschool	**0.041**	**0.117****	**0.122***	**0.020**	**0.059****	**0.149*****	**0.063***	**0.102****	**0.191****	**-0.027**	**0.051**	**0.073**
	(0.088)	**(0.053)**	**(0.069)**	**(0.059)**	**(0.028)**	**(0.049)**	**(0.038)**	**(0.043)**	**(0.078)**	**(0.036)**	**(0.035)**	**(0.052)**
Student characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Class characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	4.876***	6.055***	6.197***	4.277***	4.646***	6.136***	3.934***	4.854***	4.098***	3.844***	4.013***	3.637***
	(0.527)	(0.410)	(0.456)	(0.285)	(0.107)	(0.309)	(0.379)	(0.375)	(0.919)	(0.312)	(0.156)	(0.301)
FE: Stratum-Golfe Lomé	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Kara	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Maritime	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Plateaux	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: Stratum-Savanes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	**0.258**	**0.258**	**0.227**	**0.097**	**0.159**	**0.186**	**0.253**	**0.246**	**0.244**	**0.119**	**0.168**	**0.217**
QH (Wald test)		**^{2}= 45.540**			**^{2}= 37.840**			**^{2}= 66.020**			**^{2}= 277.030**	
Prob (^{2})		**0.000**			**0.000**			**0.000**			**0.000**	
N		**2,065**			**4,052**			**2,065**			**4,052**	

*Notes: Bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1). QH= Quantile Heterogeneity.*

6 Robustness Check

In this section, we analyze the robustness of the results using other methods, such as propensity score estimators and stratum fixed-effects Ordinary Least Squares (OLS) method. To assess the extent to which the results of the conditional quantile regression may be plagued by endogeneity, we compare results of a stratum fixed-effects Ordinary Least Squares (OLS) estimation to that of propensity score estimators: Inverse Probability Weighting (IPW), Augmented Inverse Probability Weighting (AIPW), and Inverse-Probability-Weighted Regression Adjustment (IPWRA).The rationale of this comparison is that stability of the results of the stratum fixed-effects OLS may reflect lesser endogeneity issue in the conditional quantile estimation with stratum fixed-effects.

The OLS results confirm the positive association between preschool education and subsequent school performance in reading and mathematics at Grade 2 and Grade 6 (Table 7). Specifically, preschool attendance is associated with a 0.240 SD increase in reading and a 0.166 SD increase in mathematics at Grade 2. A similar trend is observed at Grade 6, although the magnitude of the associations is slightly smaller, with estimated gains of 0.135 SD in reading and 0.111 SD in mathematics.

The estimates of IPW, AIPW and IPWRA presented in Table 8 confirm the positive association between preschool attendance and subsequent school performance in reading and mathematics, both in Grade 2 and Grade 6. The IPW estimator, calculated from the Average Treatment Effect (ATE), indicates that access to preschool education is associated with score gains, 0.219 SD in Grade 2 and 0.118 SD in Grade 6, on average for all students. In mathematics, the corresponding gains are 0.171 SD in Grade 2 and 0.096 SD in Grade 6. Considering the Average Treatment Effect on the Treated (ATT), the results show that preschool attendance is associated with improvements of approximately 0.183 SD in reading and 0.122 SD in mathematics in Grade 2. In Grade 6, the estimated associations remain positive and significant, reaching approximately 0.160 SD in reading and 0.140 SD in mathematics. It is important to note that very similar trends emerge when applying the AIPW and IPWRA estimators, which combine propensity score weighting and regression of outcomes to produce doubly robust estimates (Wooldridge, 2010).

When these estimates are compared with the results of fixed-effects OLS, which indicate gains of 0.240 SD and 0.166 SD in reading and mathematics, respectively, at Grade 2, and 0.135 SD and 0.111 SD at Grade 6, the magnitudes of the coefficients appear relatively similar across estimation methods. This consistency suggests that the potential bias related to observable and unobservable selection of children attending preschool may not completely jeopardize our main results described in the previous section. In other words, although endogeneity problems cannot be completely ruled out, the similarity between the OLS estimators and those based on IPW,

Table 7: Estimating the Association between Preschool Education and Learning Outcomes—OLS with stratum fixed-effects

	Grade 2		Grade 6	
	Reading/100	**Mathematics/100**	**Reading/100**	**Mathematics/100**
Variable of interest				
Access to preschool	**0.240*** **	**0.166*** **	**0.135*** **	**0.111*** **
	(0.042)	**(0.038)**	**(0.023)**	**(0.023)**
Student characteristics				
Student's age	0.022	0.043**	-0.084***	-0.064***
	(0.020)	(0.018)	(0.006)	(0.006)
Student boys	0.040	0.057	0.055***	0.108***
	(0.039)	(0.036)	(0.019)	(0.020)
School characteristics				
Electricity at school	0.189***	0.109***	0.243***	0.228***
	(0.045)	(0.042)	(0.022)	(0.022)
Public school	-0.058	-0.065	-0.190***	-0.090**
	(0.099)	(0.099)	(0.045)	(0.042)
School canteen	0.136*	0.229***	-0.041	-0.049
	(0.075)	(0.069)	(0.041)	(0.041)
Free public school	0.218**	0.199**	-0.052	-0.034
	(0.086)	(0.088)	(0.039)	(0.038)
Infrastructure index	0.012***	0.011***	0.009***	0.010***
	(0.003)	(0.002)	(0.001)	(0.001)
School size	0.101***	0.076***	0.064***	0.078***
	(0.013)	(0.011)	(0.006)	(0.006)
Class characteristics				
Class size	-0.003***	-0.002*	-0.010***	-0.011***
	(0.001)	(0.001)	(0.001)	(0.001)
Class equipment index	0.011***	0.006**	0.005***	0.010***
	(0.003)	(0.002)	(0.001)	(0.001)
Teacher characteristics				
Teacher's age	0.010***	0.009***	0.002	0.005***
	(0.002)	(0.002)	(0.001)	(0.002)
Male teacher	-0.092**	-0.060	-0.010	0.017
	(0.044)	(0.040)	(0.027)	(0.026)
Constant	2.326***	2.926***	4.925***	3.891***
	(0.302)	(0.264)	(0.141)	(0.142)
FE: Stratum-Golfe Lomé	Yes	Yes	Yes	Yes
FE: Stratum-Kara	Yes	Yes	Yes	Yes
FE: Stratum-Maritime	Yes	Yes	Yes	Yes
FE: Stratum-Plateaux	Yes	Yes	Yes	Yes
FE: Stratum-Savanes	Yes	Yes	Yes	Yes
R^2	**0.326**	**0.234**	**0.466**	**0.453**
N	**2,092**	**2,092**	**6,117**	**6,117**

*Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1).*

AIPW, and IPWRA indicates that they may not be at a level that would completely knock out our findings. Furthermore, the relatively small differences between these estimates and those obtained by fixed-effects conditional quantile regressions suggest that the potential endogeneity affecting the principal specification is likely marginal. This convergence of results obtained by different empirical strategies strengthens confidence in the robustness of the conclusions. Overall, these findings are consistent with a growing body of previous research showing that preschool education is positively associated with long-term cognitive performance, even after accounting for potential selection bias and the heterogeneity of treatment effects (Heckman, 2006; Duncan and Magnuson, 2013; Yoshikawa et al., 2013).

Table 8: Robustness Check: Propensity Score Estimators of the Association between Preschool Attendance and Learning Outcomes (Grades 2 and 6)

Variable of interest	Grade 2				Grade 6			
	Outcomes	**Methods**	**ATE**	**ATT**	**Outcomes**	**Methods**	**ATE**	**ATT**
Access to preschool	Reading/100	IPW	0.219***	0.183***	Reading/100	IPW	0.118***	0.160***
			(0.045)	(0.058)			(0.023)	(0.028)
		AIPW	0.218***	0.179***		AIPW	0.118***	0.159***
			(0.045)	(0.061)			(0.023)	(0.029)
		IPWRA	0.219***	0.183**		IPWRA	0.118***	0.160***
			(0.045)	(0.058)			(0.023)	(0.028)
	Mathematics/100	IPW	0.171***	0.122***	Mathematics/100	IPW	0.096***	0.140***
			(0.041)	(0.043)			(0.023)	(0.027)
		AIPW	0.170***	0.119**		AIPW	0.097***	0.139***
			(0.041)	(0.045)			(0.024)	(0.028)
		IPWRA	0.171**	0.122**		IPWRA	0.096***	0.140***
			(0.041)	(0.043)			(0.023)	(0.027)

*Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Survey sampling weights applied. Outcomes expressed in standard deviation units (PASEC score ÷ 100; population SD ≈ 1). IPW denotes Inverse Probability Weighting, AIPW denotes Augmented Inverse Probability Weighting and IPWRA denotes Inverse-Probability-Weighted Regression Adjustment. In addition, ATE denotes Average Treatment Effect and ATT denotes Average Treatment Effect on the Treated. Source: Authors' computations.*

7 Conclusion and policy implications

This study examined the distributional association of preschool education with the school performance in reading and mathematics in Grades 2 and 6 in Togo. Using several empirical strategies, including unconditional, conditional, and stratum fixed-effects conditional quantile regressions, and data from the CONFEMEN Program for the Analysis of Education Systems (PASEC, 2019), the analysis determined whether the benefits of preschool education vary according to primary school achievement levels. Additional robustness tests, based on stratum fixed-effects ordinary least squares (OLS) estimation and propensity score estimators (IPW, AIPW, and IPWRA), were conducted to ensure the stability of the results.

Overall, the results consistently show that access to preschool education is associated with improved school performance in reading and mathematics. In Grade 2, preschool education is associated with significant gains across most quantiles of performance distribution, with particularly marked associations among the lowest-achieving students in mathematics and among students of all levels in reading. These results suggest that preschool education is positively associated with outcomes across the performance distribution in Grade 2, with broadly similar magnitudes across quantiles. In Grade 6, the results indicate that the positive associations of preschool education persist, although the magnitude of the estimated coefficients decreases. In reading, significant gains remain concentrated around the median and upper quantiles of the distribution, while in mathematics, the associations are mainly observed from the median upward. These trends suggest that early cognitive investments continue to influence learning outcomes several years after starting primary school, but that their associations effects change throughout a child's educational journey.

Robust analysis confirms these findings. Ordinary least squares (OLS) estimates with fixed effects produce positive and statistically significant coefficients, indicating that preschool education is associated with score gains in reading and mathematics in Grade 2. In Grade 6, the estimated associations remain positive on reading and mathematics performance scores. The similarity between these estimates and those obtained using propensity score-based methods suggests that the results are not primarily due to endogeneity bias. By focusing on the case of Togo and using quantile regression techniques, this study sheds new light on the distributional associations of preschool education in a context characterized by significant educational inequalities. It is important to note that the quantile approach adopted in this study highlights the heterogeneity of the associations of preschool education depending on students' performance level. Rather than benefiting only average students, preschool education appears to have differently associated effects across different groups of learners. These results concerning the distribution of performance are particularly valuable for education policy, as they help determine whether early interventions primarily reduce inequalities or, conversely, exacerbate existing achievement gaps. These findings have several important implications for education policy in Togo.

First, expanding access to preschool education should be considered a central element of national education policy. Preschool enrollment rates in Togo remain relatively low, particularly in rural areas where access to preschool services is often limited. Increasing the availability of preschool programs, especially in disadvantaged regions, could significantly improve fundamental learning outcomes and reduce inequalities in preschool education. Second, policies should aim not only to increase access but also to improve the quality of preschool education. Quality early childhood programs require well-trained teachers, developmentally appropriate curricula, and suitable teaching materials. Investing in teacher training and pedagogical sup-

port is therefore essential to ensure that preschool education effectively fosters cognitive and socio-emotional development.

Third, reducing geographical inequalities in access to preschool education should be a priority. Rural communities often face significant constraints in terms of infrastructure, educational resources, and qualified teachers. Targeted investments in rural preschool structures, including community-based early childhood centers, could help reduce these inequalities and promote more equitable access to early learning opportunities. Fourth, improving the learning environment within primary schools is also essential. The findings indicate that school infrastructure, classroom conditions, and teacher characteristics play a significant role in student achievement. Policies aimed at improving school infrastructure, reducing class sizes, and strengthening teacher training programs could significantly improve learning outcomes throughout primary school. Finally, complementary social policies can also contribute to improved educational outcomes. For example, expanding access to electricity and strengthening school feeding programs could help create more supportive learning environments, both at home and at school.

Despite its contributions, this research has several limitations. First, the analysis relies on observational data, making it difficult to completely rule out potential unobserved selection bias. While the use of multiple robustness tests mitigates this risk, future research based on experimental or quasi-experimental designs could provide more accurate causal estimates. Furthermore, the study focuses primarily on cognitive outcomes measured by reading and math test scores. Although these indicators are important, preschool education can also influence other dimensions of child development, including socio-emotional skills, motivation, and behavior. These dimensions could not be fully captured by the available data. Finally, the analysis examines the average impact of preschool attendance but does not differentiate between various types or levels of quality of preschool programs. Differences in program quality can significantly influence the magnitude of the observed associations.

Future research could expand upon this analysis in several directions. Longitudinal data tracking students over a longer period would allow researchers to examine whether the benefits of preschool education persist into secondary school and beyond. Such analyses could provide valuable insights into the long-term contributions of early childhood education to human capital development and career prospects. Further research could also explore the mechanisms by which preschool education influences later school success. For example, future studies could examine whether improvements in socio-emotional skills, executive functions, or early literacy development explain the observed associations. Furthermore, evaluating preschool education programs implemented in Togo could help identify the most effective strategies for developing and improving preschool education services.

Ultimately, this study provides evidence consistent with the view that preschool attendance is positively associated with primary school outcomes in Togo, with the association persisting

— though attenuating — through Grade 6 and concentrated in the upper half of the performance distribution. By strengthening preschool education systems and integrating them into broader educational reforms, policymakers can create a more equitable and effective education system capable of supporting long-term human capital development and sustainable economic growth in Togo.

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