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Preschool participation and students' learning outcomes in primary school: Evidence from national reform of pre-primary education in Ethiopia

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ABSTRACT

This study examines whether a large expansion of pre-primary education in Ethiopia affected subsequent students' learning outcomes during the national reform of pre-primary education. The study utilizes two comparable, representative early grade reading assessment data that straddle the reform period from 2010 to 2016, during which enrolment rates in pre-primary education soared by nearly ten times nationwide. We find that associations between preschool participation and literacy outcomes were positive and significant after the expansion, yet no such relationships were observed before the reform. However, there was little heterogeneity in the gains of the preschool participation by gender, urbanity, and parental literacy. We discuss implications for ongoing reform, including strategic and inclusive policy designed to close the learning gap between children from advantaged and disadvantaged backgrounds.

1. Introduction

The expansion of pre-primary education is currently the focus of a prominent policy agenda in low- and middle-income countries. International evidence contributes to building a consensus on investing in children's early years by showing that high-quality preschool programs can have substantial impacts on children's learning and future economic returns, especially for socially disadvantaged groups (Barnett, 2011; Engle et al., 2011; Yoshikawa et al., 2013). Despite this growing evidence, investment in pre-primary education has never been sufficient (Richter et al., 2017; Zubairi & Rose, 2017), which has resulted in less than one-fifth of children in low-income countries having access to pre-primary education (UNICEF, 2019). Moreover, policymakers face the challenge of ensuring that a pre-primary education program that has proven effective in one context can retain its benefits while being made more widely available. As such, it is critical to understand the effects such an expansion could have on children's educational outcomes in countries that have no tradition of pre-primary education. This is particularly pertinent to understanding the effect of ongoing policy reform in Ethiopia, a country currently undergoing a rapid and large-scale expansion of pre-primary education.

The issue is also timely in current policy discussions about meeting the United Nations Sustainable Development Goals (SDGs), which include the explicit target of achieving universal pre-primary education at least one year before primary school entry by 2030 (Target 4.2, United Nations, 2015). Unfortunately, evidence of the effects of a large-scale expansion on children's learning remains weak and is mostly limited to high- and middle-income countries. One limitation of the current evidence base is that it is largely dependent on small, contextually limited pre-primary education program evaluations at a local or regional level. This is a critical gap, because this evidence may not be representative of the pre-primary education that could be provided at scale or nationwide (Engle et al., 2011; McCoy et al., 2017; Rao et al., 2014). This gap is pertinent to many low-income countries, where shortfalls in domestic and international funding are currently impeding the scale-up of quality pre-primary programs. Moreover, the evidence often fails to take into account the weak governance of pre-primary education (Neuman & Powers, 2021), particularly at a decentralized level. It does not account for how a government may implement the reform or whether coordinating mechanisms exist with a clear mandate on whom to lead. The evidence also has limitations in accounting for the multi-sectoral nature of pre-primary education, which makes it challenging to identify unified solutions to scale it up (Richter et al., 2017).

The aim of the present study is to fill these gaps by looking at

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Ethiopia, focusing on a nationwide policy reform in pre-primary education. We particularly pay attention to pre-primary education, the broad range of organized, site-based educational programs for children aged 4 years up to the start of primary education.[2] Ethiopia provides an important opportunity to investigate a government's policy response to expanding pre-primary education in a low-resource setting and how this reform matters in ensuring children's success in primary school. Driven by a new policy framework for early childhood care and education adopted in 2010, Ethiopia's pre-primary education landscape transformed rapidly from an elite system reserved for a few hundred thousand richer children into the mass system that now serves nearly four million young children from all backgrounds. As a result, the gross enrolment rates in pre-primary education surged from 5% in 2010–2011 to 46% in 2016–2017. The policy reform signaled the Ethiopian government's first attempt to ensure that pre-primary education is mainstreamed in all relevant national policies and programs (Ministry of Education, 2010a). Although pre-primary education reform in Ethiopia has shown impressive gains in access, little evidence is available on whether this national scale-up initiative contributes to achieving its intended policy goals—to boost students' learning outcomes and reduce learning inequalities for young Ethiopian children.

Hence, the first objective of this study is to assess whether associations between preschool participation and student's learning outcomes have changed over time by leveraging two cohorts of Early Grade Reading Assessments (EGRA) data. These large, regionally representative datasets include two cohorts of students, 9121 in 2010 and 8332 in 2016. This corresponds in particular to the period of the reform when Ethiopian children's enrollment in pre-primary increased tenfold. The datasets include comparable information, which enables us to test whether the initial associations between preschool participation and student literacy outcomes have changed during the period of reform.

The second objective of this study is to add to a limited but growing literature that explores heterogeneity in the relationships between preschool participation and student's outcomes. It examines whether the relationships between preschool participation and subsequent learning outcomes differ across child and family demographic characteristics, including gender, urbanity, and parental literacy, over time. Importantly, we use a representative sample to assess heterogeneity by subgroups instead of using a specific target group for the intervention. The differential effects of preschool are particularly important to the case in Ethiopia and similar countries, where the government has used pre-primary education to improve equity at the time of primary school entry and to narrow the learning gap throughout the education trajectory (MoE, 2015). Despite the government's efforts to reach more vulnerable children, prior research showed persistent inequalities in preschool access between advantaged and disadvantaged communities in Ethiopia (Rossiter et al., 2018). Earlier evidence in sub-Saharan Africa also demonstrated unintended results; for example, South Africa's massive rollout of pre-primary education failed to narrow learning inequality among third-grade students from wealthy communities and lower-income communities (Van der Berg et al., 2013). Thus, understanding factors that moderate the relationship between preschool participation and student's learning outcomes is critical to identifying strategies for early interventions that target specific groups of children, especially those from socioeconomically disadvantaged backgrounds. Our findings provide a foundation for understanding the effects of a large-scale expansion of pre-primary education and generate insight for the governments and organizations that are increasingly investing in it.

2. Empirical evidence on pre-primary school participation and student's cognitive development in low- and middle-income countries

In the past decade, studies in low- and middle-income countries have identified the positive effects various forms of pre-primary education programs have on individual child development, particularly on cognitive outcomes in primary school (Aboud and Hossain, 2011; Agirdag et al., 2015; Burde et al., 2015; Hungi and Ngware, 2018; Martinez et al., 2012; Nakajima et al., 2019).[3] Two studies that offer a comprehensive review of studies (Engle et al., 2011; Rao et al., 2014) presented consistent evidence on positive effects of pre-primary education programs on child cognitive outcomes across highly diverse settings. However, much of this evidence focuses on small-scale, targeted interventions for young children, from which it is difficult to generalize the effectiveness to the broader context. The responsiveness that certain sub-populations demonstrate to pre-primary education programs may differ from other sub-populations, which poses a threat to the external validity of research.

Only a handful of studies evaluate the effects of a large-scale expansion in pre-primary education, while the findings remain elusive. The studies in Argentina (Berlinski et al., 2009), rural Guatemala (Bastos et al., 2017), and Uruguay (Berlinski et al., 2008) showed the positive effects on academic achievement and educational attainment up to adolescence. Another relevant study was from South Africa, which reported small but positive effects of government-led preschool expansion on fifth-grade students' language test scores (Van der Berg et al., 2013). Contrary to this, two studies documented little effect of a large-scale experiment of preschool expansion in rural Cambodia (Bouguen et al., 2018) and rural Indonesia (Brinkman et al., 2017). Interestingly, while average impact of preschool attendance was null in both studies, opposite results emerged depending on the durations of preschool. Longer exposure to preschool in Vietnam was negatively associated with children's learning outcomes, whereas greater exposure to preschool in rural Indonesia was positively associated with children's outcomes. The authors concluded that implementation capacity, resource constraints, parents' behavioral responses, and policy environments of a particular system were significant drivers of success or failure. Collectively, these results imply that the effect of increased access to preschool could be highly context specific.

Though the focus was not the preschool expansion, two recent studies used a nationally representative sample of children in sub-Saharan Africa. In Zambia, McCoy et al. (2017) found significant and positive associations between pre-primary participation and cognitive development at school entry. In Kenya and Tanzania, Bietenbeck et al. (2017) reported the significant role preschool plays in determining cognitive outcomes by age 16. As for empirical evidence from Ethiopia in particular, only a few papers have addressed the relationship between preschool and children's cognitive development in an urban context before pre-primary programs have expanded or in a specific region. The Young Lives Study found that urban children who participated in preschool in 2006 showed better cognitive outcomes at age 8 (Woldehanna, 2016; Woldehanna and Gebremedhin, 2012), yet this preschool advantage dissipated by age 12 (Vandemoortele, 2018). With the small-scale pre-primary intervention, Dowd, Borisova, Amente, and Yenew (2016) found that Ethiopian children in the Oromia region who participated in any preschool of standard or enhanced quality showed significant improvement in early literacy and numeracy skills at ages 6 and 7, which did not occur among non-participants.

[2] In this paper, "pre-primary education" and "preschool" are used interchangeably (UNESCO Institute of Statistics, 2012). When the government policy document used other terminologies, such as early childhood care and education for provisions targeted to children aged 0–6, we adopt this.

[3] Child development includes both cognitive skills (i.e., early literacy, early numeracy) and non-cognitive skills (i.e., social skills, motivation to achieve, self-esteem, health status, and attitude towards school) (Burger, 2010). This study focuses on cognitive development such as test scores in literacy and numeracy.

Regarding the differential effects of preschool participation, prior studies from the U.S. and other high-income countries highlighted the role of pre-primary education in reducing learning disparities between rich and poor children (e.g., Magnuson et al., 2007; Weiland and Yoshikawa, 2013 for the U.S.; Berlinski et al., 2008 for Uruguay). Yet, evidence from low-income to upper-middle income countries is more mixed. First, disadvantaged children benefited more from preschool than their advantaged peers observed in Argentina (Berlinski et al., 2009) and rural Indonesia (Brinkman et al., 2017). Second, children of different family backgrounds benefited equally from pre-primary interventions in Kenya and Tanzania (Bietenbeck et al., 2017) and rural Guatemala (Bastos et al., 2017). Third, children from wealthier backgrounds obtained greater benefits than students from poorer families in South Africa (Van der Berg et al., 2013) and Turkey (Agirdag et al., 2015). While preschool can further extend the privileges of more advantaged children, some evidence raised concerns that preschool could have more deleterious effects for less advantaged children. In Cambodia, the expansion of pre-primary education failed to yield statistically significant effects overall but did identify negative associations between preschool participation and learning outcomes for children who came from poorer households or those with less educated parents (Bouguen et al., 2018). The researchers attribute the negative effects to substitution effects: some parents sent their young children to primary school (i.e., underage enrollment), while others opted to leave the education system (i.e., not enroll in school even when children become an official age for primary school). The poorer children were less likely to be in a formal school environment and showed lower outcomes.

Importantly, existing research often has limited ability to disentangle potentially distinctive effects of preschool across a nation with considerable diversity across socioeconomic classes as they exclusively targeted low-income families or those living in rural areas. The massive expansion of pre-primary education at a national scale made understanding heterogeneity in the effects of preschool participation more critical (Bassok and Engel, 2019). Research using nationally- or regionally representative samples helps us understand possible mechanisms for providing more inclusive pre-primary education experiences for children and their families when the resources are finite. In an attempt to address the evidence gap, the present study assesses whether the benefits of preschool expansion are particularly pronounced for a particular group using regionally representative samples of Ethiopian children.

3. National policy reform of pre-primary education in Ethiopia

Pre-primary education in Ethiopia targets children four to six years old before they officially enter grade 1 at age seven. Historically, it was provided on a small scale by private, non-governmental, and faith-based organizations. Ethiopia's 1994 Education and Training Policy document initially acknowledged the importance of pre-primary education for holistic development of children in preparation for formal schooling (MoE, 1994). However, due to the government's prioritization of primary and secondary education, pre-primary education was ignored by the public education sectors until 2010. As a result, the supply of pre-primary education services existed exclusively in urban areas and cities where it served less than 5% of 4- to 6-year-old children, mostly from wealthy backgrounds.

The Government's drive to expand pre-primary education emerged in 2010 when Ethiopia adopted a National Policy Framework for Early Childhood Care and Education (ECCE). The new policy framework, including parental education, health and early stimulation (prenatal to 3 years), preschools/kindergartens, and community-based non-formal school readiness programs (4–6 years), focused on the delivery of accessible, equitable and quality pre-primary education services for all children, particularly for children from disadvantaged backgrounds (MoE, 2010a). The policy framework created significant momentum for introducing various forms of pre-primary education service delivery, including 'O-Class (or zero-class)' and Child-to-Child programs, along with the existing kindergarten program mostly run by private sector organizations. O-Class has been the main focus of government provision in the framework, with free pre-primary classes for 6-year-olds attached to government primary schools. The Child-to-Child program, supported by UNICEF, relies on school-based peer tutoring (i.e., young children with older siblings or peers) to develop early learning competencies under the supervision of primary teachers. Table 1 summarizes the characteristics of the three predominant types of pre-primary education now in existence in Ethiopia, including kindergarten, O-Class, and Child-to-Child.

Large-scale government involvement in pre-primary education was reinforced by Ethiopia's fifth Education Sector Development Program (ESDP V, 2015/16–2019/20), where the government set an ambitious target for achieving universal pre-primary education for 6-year-olds and reaching 80% of 4- and 5-year-olds by 2020 (MoE, 2015). With the government's promotion of the full provision of accessible and affordable ECCE, the plan stressed that 'quality, targeted, ECCE provision will be used as a tool to increase equity in the education system' (MoE, 2015, p. 77).

Over the six-year period from 2010 to 2016, the gross enrolment rates in pre-primary education for all 4–6-year-olds rose from 5% to 50%, with rapid increases for both boys and girls, according to the Ministry of Education figures (Fig. 1). With a sudden influx of young children into the education system, it is inevitable that many challenges affecting equitable access and quality of pre-primary education provision arise. These include, for example, the lack of trained teachers/facilitators; limited availability of curriculum and teacher guides; a lack of adequate classroom facilities, insufficient developmentally appropriate learning materials and playgrounds, and lack of incentives/salary for teachers (Rossiter et al., 2018; Teferra and Hagos, 2016; Woodhead et al., 2017). Importantly, as pre-primary education in Ethiopia is continuously expanding and evolving, there is a need for evaluating the changes induced by the reform, particularly whether the reform has achieved the main goal to promote equitable access and learning for young children.

4. Study objectives

In light of the rapid shift in the pre-primary education landscape in Ethiopia since 2010, the present study aims to determine whether the relationships between preschool participation and student's literacy outcomes have changed over the reform period. By leveraging regionally representative data from two cohorts of children, this study compares the changes in these relationships between 2010 and 2016, the period in which the large-scale preschool expansion occurred. This study addresses two primary research questions:

(1) To what extent is the large-scale expansion of preschool associated with changes in the way preschool participation predicts second- and third-grade students' literacy outcomes?

Table 1
Types of pre-primary education provision in Ethiopia.

	Kindergarten	O-Class	Child-to-Child
Formal or informal	Formal	Formal	Informal
Duration	Up to three years	One year	Up to three years (part-time)
Main source of funding	Private; tuition-based	Government	UNICEF & Government
Main implementer	Private sector	Government	UNICEF & Government
Teacher	Private teacher	O-Class public school teachers	Older children
Target age group	4–6 years	6 years	4–6 years

Source: Table adapted from the *Journeys to Scale* (UNICEF, 2016).

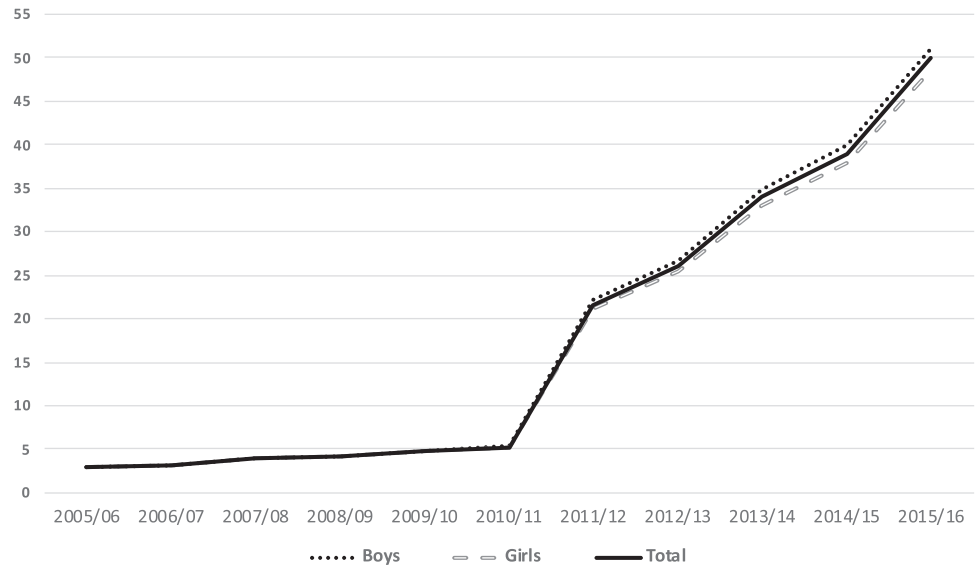

Fig. 1. Rapid increase in gross enrolment ratio in pre-primary education from 2005 to 2016. Notes. Pre-primary education provision includes kindergarten, O-Class, and Child-to-Child programs. Data from the National Education Statistics Annual Abstracts reported by the Ministry of Education, Ethiopia, 2005/06–2015/16.

(2) Do the relationships between preschool participation and students' literacy outcomes during the large-scale expansion of preschool differ across children's gender, urbanity, or parental literacy?

The aim of this study is to improve the evidence base on pre-primary education in low-income countries by exploring a nationwide expansion of preschool, rather than an initiative targeting a particular geographic sample. From a policy-oriented perspective, it is important to assess the outcomes of such expansion efforts and to determine whether all children experienced it equitably. These issues that are critical for Ethiopia provide important lessons for other resource-constrained contexts that are facing similar challenges in achieving the 2030 Sustainable Development Goal target.

5. Methodology

5.1. Data

The data used for this study are from the EGRA, an instrument used globally to assess students' early ability in reading acquisition (Gove and Wetterberg, 2011). EGRA Ethiopia is a school-based assessment that was introduced in 2010 and adapted to five of Ethiopia's local languages. The anonymized EGRA datasets were obtained through the United States Agency for International Development (USAID) Reading Network and USAID Ethiopia. The data obtained ethical clearance from the institution and complied with the USAID Development Data Policy throughout the entire process.

We used two EGRA datasets administered to Ethiopian students in primary school grade 2 and grade 3, 9121 in 2010 (pre-reform) and 8332 in 2016 (post-reform). Each round included a regionally representative sample of children from five regions in Ethiopia—Tigray, Amhara, Oromia, Somali, and the Southern Nations, Nationalities, and People's Regions (SNNP, Sidamu language only) (Fig. 2). Table 2 provides an overview of some regional characteristics of the five sample regions, which cover 94% of Ethiopia's 4- to 6-year-old population. Before the test was administered, parents of the participating schools consented to their children's participation in the assessment at school committee or community meetings, or during home visits. Each child's verbal assent was also obtained before the assessment. These processes, which were used instead of written consent due to political and cultural sensitivities in Ethiopia, align with established processes for obtaining informed consent.

EGRA, which consists of sub-tasks that correspond to the building blocks of reading acquisition, was used to ensure timely access to data that could inform learning improvement efforts in Ethiopia (Piper, 2010). EGRA has been instrumental in helping the Ethiopian government to prioritize the acquisition of literacy in the early grades. After completing six rounds of assessment since 2010, EGRA is now used to measure the progress in a government-led national education reform launched in 2018 (World Bank, 2017). The major advantage of using EGRA data for this study is that the surveys straddled the period of Ethiopia's pre-primary education reform and were administered to representative samples from the same five regions over the two time periods. This enabled us to compare the relationships between preschool participation and student's literacy outcomes before and after the policy change. Another advantage of using EGRA is its culturally and linguistically sensitive approach to reading measurement. Regional education bureaus and local language experts adapted the instrument to five Ethiopian languages and set the reading benchmarks for each language to reflect unique linguistic characteristics on the EGRA assessment (RTI, 2015).

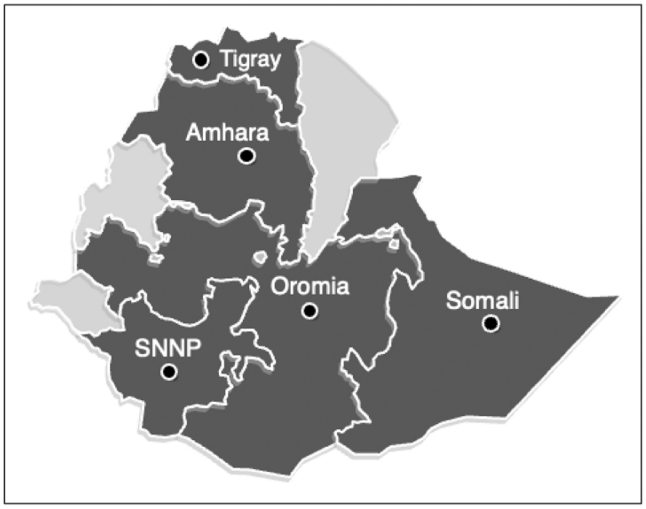

Fig. 2. Map of Ethiopia: Five sample regions.

Table 2
Characteristics of sample regions.

Region	Multi-dimensional poverty index[a]	Population (million)[b]	Population of preschool-aged children (million)	Primary net enrolment ratio[c]	Primary gender parity index[d]
Tigray	0.537	5.06	0.39	109.7	0.94
Amhara	0.588	20.40	1.73	103.7	0.96
Oromia	0.592	33.69	3.09	97.0	0.87
SNNP	0.574	18.28	1.60	109.1	0.89
Somali	0.647	5.45	0.52	72.3	0.78

[a] Multi-dimensional poverty index: Poverty index based on the health, living standards, quality of education, and empowerment indicators (Oxford Department of International Development, 2017).
[b] Population: 2015 population based on 2007 population census in Ethiopia (Ethiopia Central Statistical Agency, 2016).
[c] Primary net enrolment ratio: Total number of students of the official age group for primary education who are enrolled in primary education, expressed as a percentage of the corresponding population (MoE, 2016).
[d] Gender parity index: Ratio of number of female students to male primary school students (MoE, 2016).

5.2. Measures

5.2.1. Preschool participation

Preschool participation was collected by asking each child to report whether they had ever been enrolled in any form of preschool before entering primary school. Given the available data, students were categorized as having participated in preschool if they attended one of the three programs (i.e., kindergarten, O-Class, or Child-to-Child), regardless of the type of pre-primary education provision. Preschool participation is thus defined as a broad set of center-based or classroom-based pre-primary education programs that encompasses formal and informal, public and private institutions. Table 3 presents the mean and standard deviation of preschool variables.

The possibility of recall problems in reporting preschool participation retrospectively cannot be excluded, yet the pre-primary school participation the sample children reported is comparable to the national picture about preschool enrolment reported by providers. To check the reliability of the self-reported measure, we compared preschool participation in EGRA with the official national education statistics (Education Management and Information System, EMIS). Between 2007 and 2014, the gross enrolment rate in the national statistics soared from 4% to 41.3%, while preschool participation among the EGRA sample increased from 14.2% to 38%. Both EGRA and EMIS indicate that about 40 precent of children enrolled in preschool after the reform, while some discrepancy in the earlier years may stem from underreporting issues in the kindergarten programs run by the private sector, NGOs, and faith-based organizations (MoE, 2010b). The national figure also demonstrates that the expansion was mainly driven by O-Class, given that enrolment in different programs was stagnant or declined during the same period. The overall national enrolment trend reaffirms the unprecedented public attention given to pre-primary education in Ethiopia in recent years, as well as the accuracy of the preschool indicator used in the present study.

5.2.2. Main outcomes: literacy assessment

Academic outcomes were drawn from a direct student assessment, which was conducted at the end of the school year in both 2010 and 2016. The set of outcome variables came from the basic literacy skills measured by EGRA: oral reading fluency, reading comprehension, and the proportion of non-readers and proficient readers.[4] Our focus on the first two variables in EGRA sub-tasks were based on the selection made by the previous studies (Piper et al., 2014; Carter et al., 2020) and to ease interpretation. Oral reading fluency is an ability to read with speed and accuracy, which serves as a valid proxy for overall literacy skills (Piper et al., 2016; Piper and Zuilkowski, 2015), whereas reading comprehension is a sophisticated skill that assesses understanding of the text in a passage and the ability to answer factual questions based on what they read. As recommended by the global EGRA application (Gove and Wetterberg, 2011), test scores from the EGRA sub-tasks were used separately, rather than using the composite score. The score was the number of words read correctly per minute, or a percentage of the five items answered correctly. The analysis used standardized scores (z-scores) based on the mean and standard deviation among the sample of children who took the test.

The use of non-reader and proficient reader was important for policy purposes. The Ethiopian government developed a range of reading benchmarks in local languages to monitor students' progress nationwide and inform the policy-making process. The benchmarks were developed through data-driven consultation with regional language experts and key stakeholders (RTI, 2015). The reading proficiency level is thus defined distinctively by languages and grades based on students' test scores in oral reading fluency and reading comprehension (see Table 4). They ranged from level 1 for the lowest proficiency (non-reader) to level 4 for the fully proficient (reading with full fluency and comprehension). In this study, non-readers are students who could not read a single word of connected text correctly, a critically low performance at level 1, whereas proficient readers are those who read a given passage with high or full fluency and scored at levels 3 and 4 of the reading benchmarks.

5.2.3. Child and household characteristics

The current analysis includes a range of child and household characteristics associated with whom sent their children to preschool, which are based on prior studies in Ethiopia (Vandemoortele, 2018; Woldehanna, 2016). Importantly, the selection of these variables had to be based on the availability and comparability of the indicators across the 2010 and 2016 surveys, which were reported by the children. Key child and household characteristics included age, gender, parental literacy (whether both mother and father can read and write), living in a rural or urban area, whether or not children had access to literacy materials at home (e.g., books), and whether children use the same language at home as they are taught in at school.[5] To take regional disparities into account, we also considered the geographic region in which children live. To check the multicollinearity among control variables, we estimated the correlation and variance inflation factor (VIF). First, the correlations across the variables were low, between 0.03 and 0.14. Second, the VIF for multivariate regression was 1.31, which is far below the threshold of 10, meaning that the covariates could be considered a linear combination of other independent variables. Descriptive statistics for the control variables for the estimation sample are shown in Table 3.

The children in the sample were on average age 10 at the time of the assessment. The sample was evenly stratified by grades and gender. In both cohorts, about 80% of the children were from rural households, which reflects the average national rural-urban population ratio (World

[4] We acknowledge the interconnectivity among various EGRA sub-tasks, such as letter recognition and word recognition (Bartlett et al., 2015). We used other EGRA sub-tasks to check the robustness of our analyses and found consistent results (results are available upon request).
[5] It was not possible to include a direct measure for household socio-economic status (SES) as this was not collected in the 2016 EGRA administration. However, the survey includes indicators for parental literacy, as well as having books and other reading materials at home, which are highly correlated with SES (Piper, 2010).

Table 3
Descriptive statistics of key variables.

	2010 average		2016 average		*2010* Preschool Attendance			*2016* Preschool Attendance		
					Yes (a)	No (b)	(a)- (b)	Yes (c)	No (d)	(c)- (d)
	m	(SD)	*m*	(SD)	*m*	*m*	*Diff.*	*m*	*m*	*Diff.*
Pre-primary education enrolment										
Preschool Attendance	0.14	(0.35)	0.38	(0.49)	–	–	–	–	–	–
Early reading test scores										
Oral reading fluency (wpm)	21.78	(21.35)	21.25	(20.93)	23.79	21.42	2.37	23.85	19.66	4.19 ***
Reading comprehension (%)	0.24	(0.27)	0.23	(0.28)	0.28	0.23	0.05	0.26	0.21	0.05 ***
Share of non-reader (%)	0.32	(0.47)	0.26	(0.44)	0.34	0.32	0.02	0.19	0.30	-0.11 ***
Share of proficient reader (%)	0.39	(0.49)	0.39	(0.49)	0.44	0.38	0.06	0.46	0.35	0.12 ***
Child characteristics										
Age	10.14	(2.06)	9.84	(1.68)	9.98	10.17	-0.19	9.43	10.09	-0.66 ***
Grade	2.50	(0.50)	2.50	(0.50)	2.52	2.50	0.11	2.50	2.50	0.60
Female	0.50	(0.50)	0.49	(0.50)	0.48	0.50	-0.02	0.51	0.48	0.03 *
Household characteristics										
Parental literacy	0.31	(0.46)	0.38	(0.49)	0.47	0.28	0.19 ***	0.52	0.30	0.22 ***
Students has any additional books at home	0.21	(0.41)	0.44	(0.50)	0.30	0.20	0.10 ***	0.53	0.38	0.15 ***
Living in rural	0.82	(0.38)	0.79	(0.41)	0.66	0.85	-0.19 *	0.71	0.84	-0.13 ***
Students use the same language between home/school	0.90	(0.30)	0.94	(0.23)	0.85	0.91	-0.06	0.94	0.95	-0.01
Observations	9121		8332		1245	7876		2989	5343	

Notes: All figures were weighted by sample weight. The '*Diff*' column shows the significance based on the *t-test* estimates. wpm = words per minute. *m* = mean; SD = Standard deviation. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4
Reading proficiency level by languages and grades in Ethiopia.

Language	Region	Grade	Non-Reader	Reading slowly with limited comp	Proficient Reader		Grade difference (Grade 3 -Grade 2 in 'Level 4' benchmark
					Reading with some fluency and comp	Reading fluently with full comp	
			(Level 1)	(Level 2)	(Level 3)	(Level 4)	
			'Correct words per minute' measured by oral reading fluency				
Oromia	Afan Oromo	Grade 2	0	1–19	20–47	48	10
		Grade 3	0	1–29	30–57	58	
Somali	Af-Somali	Grade 2	0	1–24	25–49	50	5
		Grade 3	0	1–24	25–54	55	
Amhara	Amharic	Grade 2	0	1–29	30–49	50	10
		Grade 3	0	1–34	35–59	60	
SNNP	Sidamu-Afoo	Grade 2	0	1–19	20–44	45	8
		Grade 3	0	1–24	25–52	53	
Tigray	Tigrinya	Grade 2	0	1–20	20–54	55	7
		Grade 3	0	1–25	25–61	62	

Notes: In Ethiopia, the reading proficiency is defined distinctively by languages and grades. The range of each benchmark was developed through intensive data-driven consultation with the MoE, regional language experts, and key stakeholders (RTI, 2015). To establish benchmarks corresponding to students' reading performance and the national curriculum, regional language experts created language-specific metrics, such as looking at the intervals of oral reading fluency scores achieved by the students who had 40–60% correct answers on the reading comprehension test, as compared to the students who had 80–100% correct answers on the same test. The MoE and regional language experts created a group of the proficient reader, which is equivalent to the functional reader and consists of students at level 3 or above. The last column presents the difference in the highest reading proficiency level (level 4) between grade 2 and grade 3, which denotes the expected level of improvement when students progressed from grade 2 and grade 3.
Source: RTI (2015)

Bank, 2021). Children who attended preschool were more likely to be from households where both the father and mother are literate and have books at home than those who did not attend preschool. Notably, these gaps in family characteristics between the two groups widened between 2010 and 2016. Overall, the descriptive figure shown in Table 3 suggests that families that chose to send their child to preschool in 2010 were not necessarily similar to those who did so in 2016. These differences highlight the need to account for baseline differences when estimating

the relationships between preschool participation and child outcomes.

Non-response rates were very low across the two EGRA administrations. In both rounds, non-response rates were almost zero for outcome variables and preschool attendance (less than 0.05% in 2010 and none in 2016), and for covariates (less than 0.02% for both). Considering the very low item non-response, the present study used listwise deletion, also known as complete case analysis, which is less likely to introduce bias if the data are "missing at random" and provide accurate estimates of true standard errors (Allison, 2002).

5.3. Empirical strategy

We use four sets of empirical strategies to assess the relation between preschool participation and student's literacy outcomes, and whether this relation changed between 2010 and 2016. First, we estimated a multivariate ordinary least square (OLS) model to show average differences in outcomes between children who attended preschool and children who did not attend preschool. Each of the outcome variables was regressed upon preschool participation with a set of covariates, as indicated here:

$$Y_{is} = \beta_0 + \beta_1 PRE_{is} + \beta_2 X_{is} + \beta_3 F_{is} + \epsilon_{is} \quad (1)$$

where Y_{is} represents a measure of literacy skills (i.e., test scores) for child i in school s; PRE_{is} represents a binary variable equal to 1 for children who participated in preschool; X_{is} and F_{is} represent covariates, each denoting child and household characteristics, including regional dummies (i.e., regional fixed effects that address between-region variations). β_1 to β_3 are the respective coefficients for these three vectors, and ϵ_i is an error term (residual) that captures unmeasured factors.

For the binary outcome variables (e.g., whether students cannot read at all), we used a linear probability model instead of a logistic regression model, due to its greater stability in estimating relative differences between children who attended preschool and those who did not. Recent evidence confirms the accuracy of predictions in the linear probability model as compared to logistic regression estimates (Angrist and Pischke, 2008; Alcott and Rose, 2017; Chatla and Shmueli, 2017).[6] This was important to our study to ease interpretation across different outcome variables, and when including interaction terms to address the second research questions.

Second, to account for school-level variance in pre-primary provision, we used a school fixed effects model by comparing student's learning outcomes within the same schools. Given that preschool attendance may vary across communities due to the availability, accessibility, and affordability of preschools, it is important to account for variations in school-level characteristics that often are unobserved and time invariant (Clarke et al., 2015). We added school dummies in the OLS model for this estimation.

Third, to estimate the effects of preschool on an individual child who is likely to attend preschool, we utilized a propensity score matching model. We noted that both OLS and school fixed effects models explore the average treatment effect of preschool participation by comparing preschool participants with those of a heterogeneous group of non-participants in baseline characteristics (see Table 3 for details on the differences). Compared to OLS and school fixed effects models, propensity score matching enabled us to account for observable sources of nonrandom selection into preschool in order to identify a credible counterfactual of preschool participants and non-participants. Propensity score matching is widely used to draw sound inferences in empirical studies that evaluate the effects of preschool participation (e.g., Goodman and Sianesi, 2005; McCoy et al., 2017).

Using a kernel density matching approach (Heckman et al., 1998), we matched preschool participants and non-participants, based on a list of child and household characteristics used in this study. Kernel-based matching is a nonparametric matching approach that compares the outcomes of preschool participants to a weighted average of the outcomes of all preschool non-participants, with weights inversely proportional to the distance of propensity scores between the two groups. After the iterative process of modifying the propensity model specifications, the model achieved a better overall balance on each potential confounder (Appendix A for more details). To reduce bias, we estimated the preschool coefficient based on the matched data, using an OLS regression model in which the treatment indicators and all confounders were included in the post-match analysis (Abadie and Imbens, 2002; Rosenbaum and Rubin, 1985). We consider this our primary analytic approach for the present study. The regression models were run separately for two cohorts on the change in the relations during the expansion. In all models, the survey weights have been applied to ensure regional representativeness.

Fourth, we use a difference-in-difference (DID) approach as a sensitivity check to determine whether there are statistically significant differences in the relations between preschool attendance and student outcomes that have changed between 2010 and 2016. DID models compare changes in students' outcome variables (literacy achievement) at two different assessment points for the treatment and control groups (preschool participants vs. non-participants). By accounting for changes in outcome for the control groups over time, the DID approach allows the analysis to separate treatment effect from changes in the population that are not due to treatment effect (Murnane & Willett, 2010). In the DID model, we introduce time (T_{Year}=2010, 2016), the treatment variable (PRE_{is}), and the interaction term between the time and treatment variables (T_{Year}*PRE_{is}), with the inclusion of control variables (X_{is} and F_{is}).

In addressing our second research question on the heterogeneity effects by child and family characteristics, we estimate the model in which the indicator for preschool participation interacts with one potential moderator—gender, location, and parental literacy. This approach with interaction terms helped us in particular to see whether their joint associations are significantly greater (or significantly less) than the sum of the parts. For example, what we are looking for is not merely whether boys and girls have different learning outcomes, but whether boys' outcomes are significantly different from girls' outcomes when both participated in preschool. It helped us elucidate who would demonstrate greater gains in early literacy from preschool participation—between girls and boys, children living in rural versus urban areas, and children with literate parents versus those with parents who are not literate.

To capture a difference in the relationships between 2010 (pre-reform) and 2016 (post-reform), each model was estimated twice (except DID) for four different outcome variables. We used a Bonferroni adjustment to detect statistical significance across the same statistical models using multiple outcome variables. We have the hypothesis for the null being rejected at a 5% level, with the models regressed upon four outcome variables in each cohort, thus the p-value that we would accept for statistical significance was less than 1.2%, which is close to 1%. Hence, we only accepted 1% as a statistically significant result across multiple analyses used in this study.

6. Results

6.1. Preschool participation: a rapid shift in the pre-primary education landscape from 2010 to 2016

Fig. 3 offers a descriptive picture of the distribution of the school-level average of pupils who participated in preschool, stratified by urban and rural location. Regardless of location, the enrolment distribution, which presented a skewed right curve in 2010, shifted to a close to normal distribution in 2016 (or was less skewed for rural). In 2010,

[6] All models were replicated with logistic regression as an additional check, which yielded similar estimates.

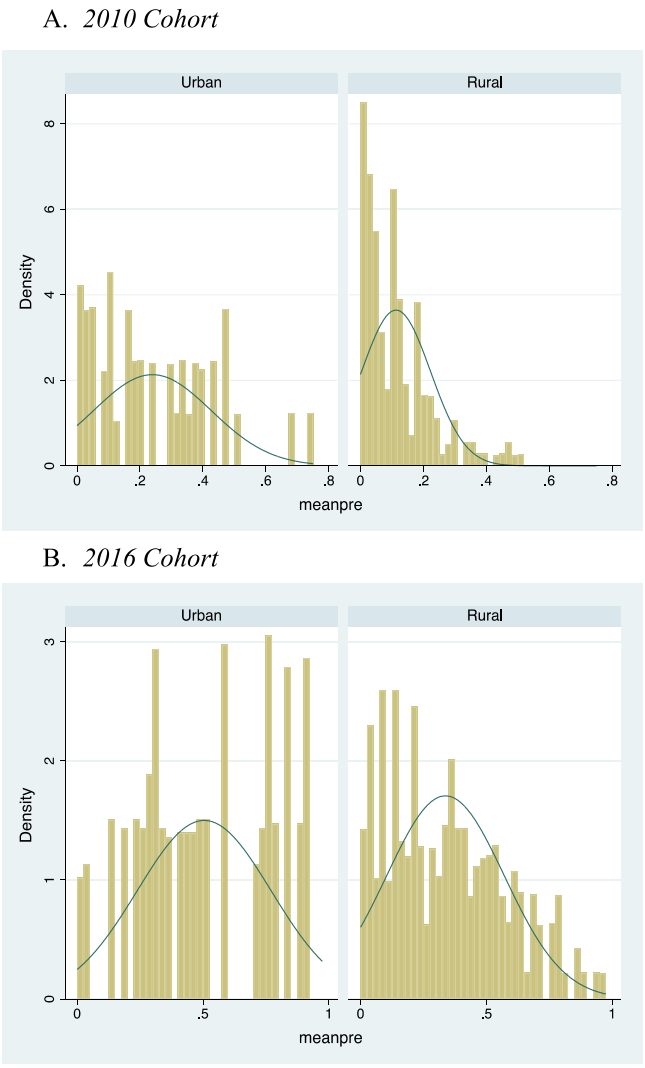

Fig. 3. Kernel density of school-level average of pupils who enrolled in preschool by year and location. Note. The graph bars denote the school-level average of pupils who participated in preschool across 237 schools in 2010 and 225 schools in 2016.

the proportion of children who participated in preschool was 27.4% for those living in an urban area and 11.4% for those living in a rural area. In 2016, this proportion increased significantly in both locations: 50% of children from urban areas and 34% of children from rural areas participated in preschool before they entered formal schooling. Notably, preschool participation in rural areas showed a steeper increase than in urban areas between 2010 and 2016, although it still lagged behind preschool coverage in urban areas. This figure depicts how access to preprimary education in Ethiopia shifted rapidly from the existing elite system to a more accessible system created by the reform.

6.2. Preschool participation and student's literacy outcomes

Table 5 shows the results of our main regression analyses, which used multiple model specifications to measure the predictive role of preschool in student's literacy outcomes—OLS, school fixed effects, propensity score matching. Using the DID model, it also shows the comparison between the pre-reform (2010) and post-reform (2016) periods. To account for the possibility of correlated errors across individuals nested in school, all models included robust standard errors clustered at the school level.

We find that, in 2010, before the reform, there was no positive association between preschool participation and student's literacy outcomes in grades 2 and 3. Yet, this relationship was reversed for the 2016 cohort, after the large-scale expansion of preschool: in basic literacy, students who participated in preschool significantly outperformed students who did not participate in any preschool. Based on the estimates of the OLS with standardized score (z-score), the magnitude of the association in 2010 was 0.02 SD in oral reading fluency and 0.05 SD in reading comprehension, which was statistically insignificant; however, the magnitude increased significantly in 2016–0.20 SD in oral reading fluency and 0.18 SD in reading comprehension. When we translate our results to the raw score, the magnitude of the association in 2010 was 0.46 words per minute in oral reading fluency and 1.34% of correct answers in reading comprehension on average. In 2016, the magnitude increased notably to 4.20 words per minute in oral reading fluency and 4.67% of correct answers in reading comprehension. The 2016 results could be seen as a significant improvement, particularly in oral reading fluency. As presented in Table 4, the expected learning progress to become a fluent reader between grade 2 and grade 3 is from 5 words per minute in Somali to 10 words per minute in Amhara; thus, the average improvement in reading fluency among the 2016 cohort can be equivalent to half to one academic year. Yet, albeit statistically significant, the improvement in reading comprehension is minimal among the 2016 cohort, which is equivalent to answering only 0.25 more items correctly when a child attended preschool.

This result is consistent with two outcome variables for non-readers and proficient readers. Using results for non-readers in the 2016 cohort, children who participated in preschool were 12% points less likely to get zero scores in oral reading fluency than those who did not participate in preschool. Similarly, preschool participants in the 2016 cohort were 7% points more likely to achieve a minimum reading fluency benchmark (e.g., 35 words per minute for third-grade Amharic-speaking children) than non-participants; there is no such significant association for the 2010 cohort. The propensity score matching model, where children were matched on the full list of covariates presented in Table 3, shows the same magnitude of association with those from the OLS models, which confirms the robustness of our findings. The magnitude of association was likely to be lower in the school fixed effect model, but it also remained statistically significant at the 1% level.

At the bottom of Table 5, we show estimates from the DID to test whether preschool participation has a differential effect before and after the reform. In this model, our main interest is the DID parameter, which is the interaction term between the time (2010 vs. 2016) and preschool variables. The results show that the large-scale expansion of preschool has significant and positive effects on students' literacy outcomes in primary school. The students' improved literacy outcomes associated with preschool participation by 0.20 SD in oral reading fluency, and by 0.18 SD in reading comprehension. The expansion's effect on the proportion of non-readers and proficient readers were also positive and statistically significant. The results of the DID estimation are consistent with the different models that compare the two cohorts separately.

In sum, the association between preschool and students' learning outcomes has changed between 2010 and 2016. A positive and significant link between preschool and student outcomes is apparent only after the large-scale expansion across all models we tested. Notably, the preschool parameters derived from the OLS, propensity score matching, and DID models were mostly identical, which reaffirms the robustness of our findings.

6.3. Subgroup results by child and family characteristics

In countries where public-sector resources are limited, it is important to understand whether interventions benefit the disadvantaged more than the advantaged to narrow the learning disparities between the two groups. Our second question focused on whether the relationships between preschool participation and students' outcomes differ by gender, urbanity, and parental literacy, and how it has changed between 2010

Table 5
Associations between preschool participation and literacy outcomes.

Variable	*2010 (Pre-reform)*				*2016 (Post-reform)*			
	Oral reading fluency	Reading comp.	Non-reader	Prof. reader	Oral reading fluency	Reading comp.	Non-reader	Prof. reader
	z-score	*z-score*	%	%	*z-score*	*z-score*	%	%
OLS								
Preschool	0.02	0.05	0.01	0.01	0.20 ***	0.18 ***	-0.12 ***	0.07 ***
(SE)	(0.07)	(0.06)	(0.03)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)
Observations	9121	9121	9121	9121	8332	8332	8332	8332
R-squared	0.20	0.19	0.16	0.11	0.26	0.19	0.21	0.14
School Fixed Effects								
Preschool	-0.02	0.00	0.04	0.03	0.12 ***	0.11 ***	-0.08 ***	0.02
(SE)	(0.09)	(0.08)	(0.03)	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)
Observations	9121	9121	9121	9121	8332	8332	8332	8332
# of schools	237	237	237	237	225	225	225	225
R-squared	0.10	0.09	0.07	0.04	0.11	0.12	0.07	0.05
Kernel-based Propensity Score Matching								
Preschool	0.01	0.02	0.01	0.01	0.20 ***	0.17 ***	-0.11 ***	0.06 **
(SE)	(0.08)	(0.08)	(0.03)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)
Observations	9060	9060	9060	9060	8178	8178	8178	8178
R-squared	0.19	0.18	0.15	0.10	0.27	0.19	0.20	0.14
Difference-in-Difference (sensitivity check)								
Preschool					0.08 ***	0.08 ***	-0.02 *	0.02
(SE)					(0.03)	(0.03)	(0.01)	(0.01)
Time					-0.10 ***	-0.08 ***	0.01 *	-0.09 ***
(SE)					(0.02)	(0.02)	(0.01)	(0.01)
Preschool X Time					0.20 ***	0.18 ***	-0.11 ***	0.09 ***
(SE)					(0.04)	(0.04)	(0.02)	(0.02)
Observations					17,453	17,453	17,453	17,453
R-squared					0.16	0.12	0.15	0.07

Notes. All figures were weighted by sample weight. For school fixed effects model, *within* school R-squared estimates were presented. PSM used the sample within the common support area. Coefficients for gender, grade, age, parental literacy (both father and mother are literate), access to books or reading materials at home, living in rural areas, same language used between home and school, and five regional dummies (region fixed effects) are included as control. SE = Standard error. *** $p < 0.01$, ** $p < 0.05$, *$p<0.1$.

Table 6
Associations between preschool participation and literacy outcomes moderated by gender, location and parental literacy.

Variable	*2010 (Pre-reform)*				*2016 (Post-reform)*			
	Oral reading fluency	Reading comp.	Non-reader	Prof. reader	Oral reading fluency	Reading comp.	Non-reader	Prof. reader
	z-score	*z-score*	%	%	*z-score*	*z-score*	%	%
Gender								
Pre-primary	0.04	0.05	0.01	0.02	0.16 ***	0.11 *	-0.10 ***	0.06 ***
(SE)	(0.08)	(0.08)	(0.04)	(0.03)	(0.04)	(0.04)	(0.02)	(0.02)
Female	-0.14 ***	-0.08 *	0.06 *	-0.05 **	0.08 *	0.10 **	-0.01	0.06 **
(SE)	(0.04)	(0.04)	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)
Pre-primary X Female	-0.04	-0.01	0.01	-0.02	0.09	0.14 *	-0.03	0.02
(SE)	(0.07)	(0.09)	(0.03)	(0.04)	(0.06)	(0.06)	(0.02)	(0.03)
Location								
Pre-primary	-0.12	-0.01	0.05	-0.00	0.29 ***	0.19	-0.15 ***	0.13 **
(SE)	(0.11)	(0.09)	(0.05)	(0.03)	(0.09)	(0.10)	(0.04)	(0.05)
Rural	-0.40 *	-0.34 *	0.08	-0.14 *	-0.24 **	-0.29 **	0.04	-0.11 *
(SE)	(0.16)	(0.15)	(0.05)	(0.05)	(0.09)	(0.10)	(0.04)	(0.04)
Pre-primary X Rural	0.20	0.09	-0.05	0.02	-0.12	-0.02	0.04	-0.08
(SE)	(0.11)	(0.10)	(0.06)	(0.04)	(0.09)	(0.11)	(0.04)	(0.05)
Parental Literacy								
Pre-primary	0.02	0.04	0.01	0.00	0.17 ***	0.15 ***	-0.13 ***	0.05 *
(SE)	(0.08)	(0.07)	(0.04)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)
Literate parents	0.08	0.08	-0.03	0.02	0.07 *	0.07	-0.05 ***	0.04
(SE)	(0.06)	(0.05)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Pre-primary X Literate parents	0.02	0.02	-0.01	0.02	0.07	0.06	0.03	0.04
(SE)	(0.10)	(0.10)	(0.04)	(0.05)	(0.05)	(0.06)	(0.03)	(0.03)
Observations	9121	9121	9121	9121	8332	8332	8332	8332
R-squared	0.19	0.17	0.16	0.10	0.26	0.19	0.20	0.14

Notes. All figures were weighted by sample weight. PSM used the sample within the common support area. Coefficients for gender, grade, age, parental literacy (both father and mother are literate), access to books or reading materials at home, living in rural areas, same language used between home and school, and five regional dummies (region fixed effects) are included as control. SE = Standard error. * ** $p < 0.01$, * * $p < 0.05$, *$p<0.1$.

and 2016. These results are the estimates from the propensity score matching model, the primary analytic approach of this study.

Table 6 first shows estimates from the regression, in which the indicator for preschool participation is interacted with a gender variable to test the differential benefits of preschool between girls and boys. While the results suggest that girls who participated in preschool slightly outperformed boys who participated in preschool in 2016, this difference is never statistically significant. Similarly, we were not able to find differential benefits of preschool by urban or rural location and parental literacy. Among those who attended preschool, rural students show lower performance in basic literacy than urban students, but the difference is not statistically significant. When we examined whether preschool benefits differ when both parents in the household are literate, there were again no consistent differences between groups. We also assessed whether gains from preschool differ when at least one parent is literate, and it showed consistent results that no differences existed between groups. Lastly, we estimate the interaction with other family characteristics, such as having reading books at home or using the same language between home and school, as a robustness check. We consistently found non-significant differences between sub-groups (The results are available upon request).

7. Discussion

Achieving universal pre-primary education by 2030 is an explicit target of the UN Sustainable Development Goals. Policymakers have sought strategies to scale-up preschools and reach all young children while ensuring their effectiveness, as evidenced by improved student learning outcomes. In this study, we examined this issue in the context of Ethiopia, one of the countries in sub-Saharan Africa that is experiencing a rapid expansion of preschool (UNICEF, 2019). Using two large and comparable datasets, we investigated whether the relationships between preschool participation and primary school learning outcomes have changed since the reform and the heterogeneity in these relationships by child and family characteristics. Given the constraints of the data, our findings could be interpreted as associations, not as causal inferences.

Our study findings show a positive and significant association between attending preschool and student's subsequent literacy outcomes in the post-reform period, but not for the pre-reform period. This finding may counter the conventional hypothesis that a sudden influx into the school system of many previously excluded young children could stagnate or deteriorate the average students' performance, as observed during the implementation of universal primary education (Dom, 2010). One possible explanation for this finding could be changes in the children's proximal (i.e., family context) and distal environments (i.e., social and economic systems) (Bronfenbrenner, 1979, 1986). In short, the rapid increase in preschool access in Ethiopia as a result of education policy reform has coincided with rapid economic growth, reduced poverty, and increases in the adult literacy rates in the country. For instance, between 2005/06 and 2015/16, Ethiopia's economy experienced accelerated growth averaging 10.3% a year, compared to a regional average of 5.4% (World Bank, 2018). Between 2011 and 2016, the female and male literacy rates increased from 27% to 40%, and from 48% to 62%, respectively (Central Statistical Agency, 2016). This implies that the preschool participants who flooded the system were likely to be the beneficiaries of economic development in Ethiopia, while those who remained without access to preschool were their disadvantaged counterparts, who are among the country's more marginalized. It may relate to greater selection bias for preschool non-participants, given that rapid economic growth often leads to a widening of inequalities between rich and poor (Kuznets, 1955). This phenomenon is also relevant to the Matthew effects (Walberg & Tsai, 1983), wherein an initial advantage leads to a cumulative advantage over time, thereby creating a virtuous cycle of continuous gain. This is often summed up as "the rich get richer and the poor get poorer."

This is supported in particular by recent evidence from Rossiter et al. (2018), which shows that, since the 2010 reforms, inequalities in access to pre-primary school persist between Ethiopia's advantaged and disadvantaged communities. During the initial uptake of the reform, wealthier families were likely to benefit more from the expansion than lower-income families, as they had better information about the reform and more resources to implement it. Although the reform has boosted enrolment rates in rural areas, analysis of national education statistics reveals that rural areas with O-Classes have relatively better access to basic services and more community contribution than rural areas without any O-Classes (Rossiter et al., 2018).

Moreover, given that there has been more heavy investment in primary education over this period, another plausible explanation is that improvements in children's learning may come from changes that occurred at primary schools rather than the reform of pre-primary education. The pre-primary reform between 2010 and 2016 overlapped with two large-scale reforms of primary and secondary education—General Education Quality Improvement Program I (2009–2013) and II (2013–2019). These reforms primarily aimed to improve the learning environment and conditions in schools, providing support to students through the supply of textbooks and learning materials, improving the teacher training systems, and promoting school-based management through school grants. Nevertheless, prior studies that assessed the effects of the primary education reform initiatives in Ethiopia revealed that academic achievement has not yet been improved between the pre- and post-reform cohorts (Woldehanna et al., 2016; Tiruneh & Rolleston, forthcoming). Although the reform has contributed to extra resources to enrich the teaching and learning processes, a clear link between a more conducive learning environment and students' outcomes remains elusive.

Although there are various contextual factors to consider (e.g., teacher qualifications, financial resources for pre-primary), the findings of this study are consistent with evidence from prior studies that have documented the moderate impact of large-scale preschool expansion on students' educational outcomes in Argentina (Berlinski et al., 2009), South Africa (Van der Berg et al., 2013), and rural Guatemala (Bastos et al., 2015). It also complements emerging evidence in sub-Saharan Africa that used nationally representative samples to elucidate the benefits of preschool attendance on school readiness in Zambia (McCoy et al., 2017). Studies in Ethiopia prior to the reform were confined to urban children (Woldehanna, 2016) or targeted just one region in the country (Dowd et al., 2016; Wolf et al., 2017). The findings of this study distinctively cover the areas where 94% of Ethiopia's 4- to 6-year-old children live, while reflecting a shift in the education system landscape. This important lesson may lead future investigations to monitor the trends and outcomes of such expansion efforts in terms of short- and long-term learning outcomes. This would help inform policy and programs in the rapidly evolving pre-primary education sector.

Unpacking these results by gender, urban or rural location, and parental literacy reveals little degree of heterogeneity across sub-groups. We did not find any differential effects of preschool participation by gender before or after the reform. While only a handful of studies have addressed the gender gap at the pre-primary level, our finding is consistent with the evidence from the previous studies in low- and middle-income countries. To illustrate, no significant gender differences were found in the benefits of preschool for later academic performance in Argentina (Berlinski et al., 2009), rural Guatemala (Bastos et al., 2017), Kenya and Tanzania (Bietenbeck et al., 2017), and Turkey (Agirdag et al., 2015).

Importantly, the findings of the current study show little support for the compensatory hypothesis that assumes the benefits of preschool participation will be greater for the disadvantaged than the advantaged. There is no outstanding advantage from attending pre-primary that accrues to children living in rural areas or whose parents who are not literate over those living in urban areas or whose parents are literate. Contrary to the compensatory effects of preschool participation that have been widely supported by evidence from the U.S. and other high-

income countries (e.g., Dearing et al., 2018; Magnuson and Duncan, 2017) and from other middle- and lower-income countries (e.g., Engle et al., 2011), prior studies in sub-Saharan Africa often fail to provide such evidence that access to pre-primary education benefits the disadvantaged over advantaged. To illustrate, in studies that used a large, nationally representative sample, children from socio-economically disadvantaged families made the same progress as their more advantaged peers in Kenya and Tanzania (Bietenbeck et al., 2017). Given that successful preschool programs in the U.S. targeted low-income families (e.g., Perry Preschool program), it is important to provide more targeted support for children from disadvantaged backgrounds instead of ambitiously targeting universal preschools for all.

The present study results suggest that expanding pre-primary education may not help to close the gap in learning outcomes between children from poorer and wealthier backgrounds. Moreover, the learning gaps could in fact increase over time, due to the cumulative advantages for preschool participants and cumulative disadvantages for non-participants. Although this is beyond the scope of this analysis, it implies that the hypothesis that preschool participation compensates for children's limited exposure to stimulating environments may hold when certain conditions at home and in school are meeting their early childhood development needs before pre-primary school entry (Burger, 2010; Engle et al., 2011). This encompasses a nurturing home learning environment, parental involvement in children's early development, and a well-resourced early child care and education system.

8. Limitations

Although the EGRA data provided a unique opportunity for the current study, several limitations should be noted when interpreting our results. First, despite the fact that preschool measures and all other variables were constructed in exactly the same way between 2010 and 2016, a few differences (e.g., how to deal with external barriers, such as security concerns during the sampling and data collection procedure) could remain between the two EGRA administrations. Second, in terms of the variable of interest, EGRA data provided a broadly defined measure of children's preschool participation, thus it was not possible to obtain specific information about the pre-primary education institutions they attended, such as type, quality, and duration. We also cannot exclude the recall bias as it was collected retrospectively. We attempted to ensure the reliability and accuracy of the preschool measure used in the study by comparing EGRA with the national education statistics (i.e., preschool enrollment, the type of institutions a child attend during the reform), given both are school-based data collection. Unfortunately, there were no household surveys in Ethiopia that collect indicators on pre-primary participation during the reform period.

Third, students' outcome measures were narrowly defined as basic literacy, due to the data availability; other measures, such as children's behavior and socio-emotional development, would have enriched our study findings. Lastly, while EGRA has the advantage of being simple and quick to administer, it has been criticized for its high dependency on oral reading fluency. The link between the fluency measure and the reading comprehension measure has been questioned, and some have argued that it is possible to read slowly but with high accuracy and comprehension (Bartlett et al., 2015; Dowd & Barlett, 2019). Children who fall into this category might not read fast enough to finish the passage in a minute and would therefore not have the time to attempt all five comprehension items. While the literacy measures used in this study may not comprehensively capture children's literacy comprehensively, a more sensitive approach to reading acquisition is needed that varies according to language and cultural context. Lastly, although this study used several different strategies to mitigate selection bias linked with preschool participation, our findings can only be interpreted as an association. They cannot directly be given causal inference.

9. Conclusion

Many low- and middle-income countries have recently expanded access to pre-primary education as an instrument for promoting human capital creation and accumulation. However, evidence is particularly lacking in Sub-Saharan Africa, where the potential for policy interventions in early childhood development is much greater than in any other region.

In this light, our study findings have important and broad implications for future policymaking and research. First, removing barriers to pre-primary access for children who are deprived of early learning opportunities should be an important first step. Despite showing considerable benefits of preschool participation, our findings call for immediate attention to educational inequality. If it remains unaddressed, the learning gaps associated with preschool would diverge further over the children's education trajectories. Second, our results point out that pre-primary participation did not effectively compensate for social disparities in learning. These results reinforce the need for future work that explores the programmatic, contextual, and individual factors that are likely to have greater benefits for children from disadvantaged backgrounds and for making evidence-based decisions about ongoing pre-primary education reform. The attention of policymakers should be not only on improving the quality of current service provision to maximize the gains from preschool but also on promoting the inclusion of communities that still do not have access to any form of preschool.

This study offers future directions for research about the conditions under which scaled-up preschool can yield meaningful and sustained benefits. While evidence exploiting significant policy shifts with non-experimental designs is instrumental, future research using household-level data and experimental designs may provide more definitive answers about the impact of expanding access to pre-primary education on children's learning outcomes. This study also captures the inception stage of early learning reform, but the reform in Ethiopia is far from static, and policy efforts are increasingly oriented toward improving quality. Studying the effects of these improvement efforts would inform potential effective and equitable ways to scale-up pre-primary education in low- and middle-income countries.

CRediT authorship contribution statement

Janice H. Kim: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft preparation, Visualization.

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Appendix A. Propensity score matching

The present study used the propensity score matching model (see Table 5). The propensity score matching (PSM, Rubin and Rosenbaum, 1983) is a widely used quasi-experimental method in observational studies. PSM emulates a situation of randomized experiments by modeling the treatment assignment patterns directly and creating sub-groups which match in their likelihood of belonging to either a treatment or a control group.

The PSM model was carried out in three steps. First, each student's propensity score was estimated using a logit regression model. The choice between logit and probit models is not critical for the current

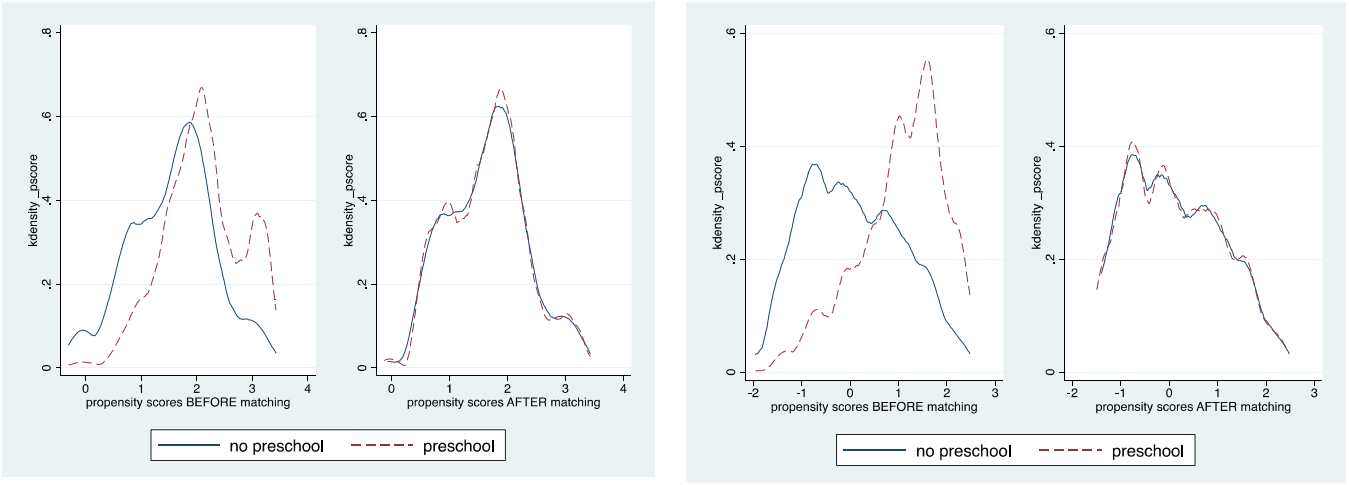

Fig. A.1. Common Support Area for Preschool Participants and Non-Participants. *Note:* In EGRA 2010, 61 students are out of common support (7876 no-pre; 1184 pre; 9060 total); In EGRA 2016, 114 students are out of common support (5316 no-pre; 2862 pre; 8178 total).

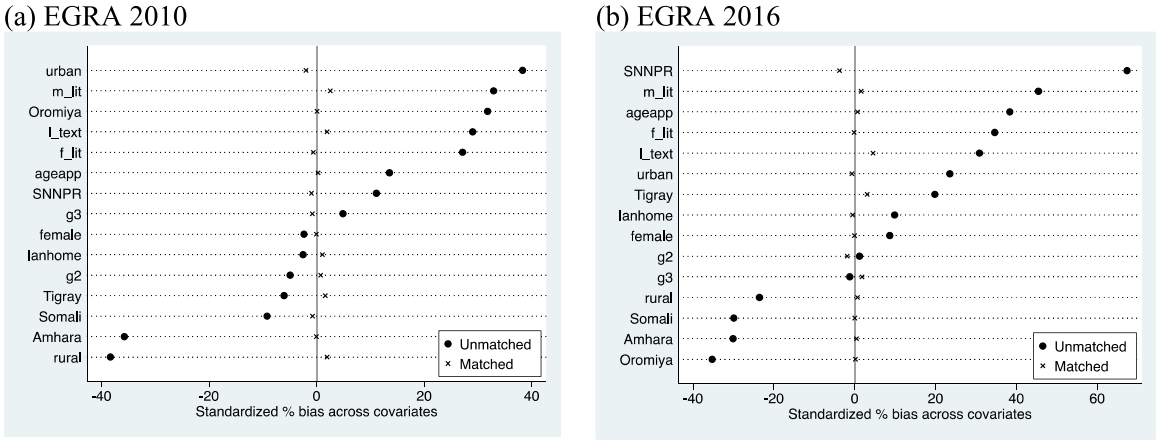

Fig. A.2. covariate balance between Matched and Unmatched Groups.

analysis, as the two models yield similar results for a binary treatment case (Caliendo and Kopenig, 2008). Second, based on the predicted probability of preschool attendance, a kernel matching approach (Heckman et al., 1998) was employed to pair preschool participants and non-participants. Kernel matching uses more information for each match, thus lower variance is achieved than traditional propensity scores matching approaches.

We examined the validity of the matching model by testing two key PSM assumptions: common support and covariate balance (Reynolds and Desjardins, 2009). Figure A.1 presents the common support areas (i.e., probability densities) before and after the matching. Compared to the limited overlapped areas before matching (left panel of each cohort), the projection after kernel-based matching (right panel of each cohort) presents a great deal of overlap between preschool participants and non-participants. This supports establishing the comparability of the treated and untreated groups.

We also checked the covariate balance and modified the propensity model specifications to establish a credible counterfactual. Figure A.2 is a visual presentation of standardized differences and associated percentage bias by unmatched and matched groups (Caliendo and Kopenig, 2008). This figure captures how the matching procedure contributes to the convergence of associated percentage bias into zero in each of the covariates. According to the threshold set to 0.20 (Rosenbaum and Rubin, 1985), standardized percentage bias across covariates (observed characteristics) displays excellent balance, closer to zero, for both EGRA cohorts.

In the final step of the kernel matching analysis, the treatment effect of preschool attendance (i.e., the average effect of treatment on the treated, ATT) on each outcome measure was estimated separately for each of the cohorts. To reduce bias, We estimated the preschool coefficient based on the matched data using an OLS regression model in which the treatment indicators and all confounders were included in the post-match analysis (Abadie and Imbens, 2002; Rosenbaum and Rubin, 1985).

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