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This study examines the long-term effect of preschool participation on children's academic achievements and the moderating role of family socioeconomic status on the association between preschool participation and later academic achievements. The study uses data from Young Lives Ethiopia, which tracked children over 15 years, and vocabulary, math, and reading scores are used as indicators of academic achievements. The ordinary least squares（OLS）regression analysis is applied to estimate the association of preschool participation with later academic achievements. The estimated results show preschool participation positively correlates with late academic achievements. The effect persists until age 15. Overall, there is no moderating role of family socioeconomic status. These results suggest that investment in preschool programs is critical for low and high socioeconomic backgrounds to foster human capital accumulation. This study does not find strong evidence that preschool participation contributes to decreasing or increasing the socioeconomic status gap for later academic achievements.

Keywords   preschool participation, long-term effect, children's developmental outcomes, Ethiopia

1   Introduction

Public investments in early childhood education are critical in forming the foundation for life-long learning and allowing children to reach their full potential（Black et al., 2017；Cunha & Heckman, 2007；Currie & Almond, 2011）[1]. Studies in the fields of health, neuroscience, and psy-

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chology support the view that cognitive and non-cognitive stimulation in early life is critical for long-term skills development, as crucial brain pathways for subsequent learning and lifelong capabilities begin to form during the early stages of life（Kautz et al., 2014；Zubairi & Rose, 2017）. Empirical evidence shows that providing high-quality preschool programs for disadvantaged children has the potential to reduce social disparities within and among countries（Heckman, 2006）. However, 250 million children（around 42%）under five worldwide are at risk of insufficient development, especially in low- and middle-income countries, influenced by risk factors such as poverty, poor parenting practice, lack of child stimulation, and insufficient nutrition（Black et al., 2017；Cprek et al., 2020；Gil et al., 2020；Walker et al., 2011）.

To support early childhood development at young ages, many countries and international organizations, including Organisation for Economic Co-operation and Development（OECD）, United Nations Educational, Scientific and Cultural Organization（UNESCO）, United Nations Children's Fund（UNICEF）, and the World Bank, have prioritized early childhood development programs in various domains：health and nutrition, preschool, parental capacity building, and social protection and welfare（Britto et al., 2011；Denboba et al., 2014；UNESCO, 2022；UNICEF, 2017）. National governments in low- and middle-income countries（e.g., Argentina, Kenya, Nigeria, South Africa, and Tanzania）started to implement policy reforms to expand access to quality preschool programs（e.g., Baum et al., 2019；Haque et al., 2013；Kim, 2022；Richter & Samuels, 2018）. In Ethiopia, the government started implementing a policy reform in the early childhood education sector in 2010 and tried to increase participation rates among children aged 4 to 6（Ministry of Education, 2015）. As a result, the enrollment rate in pre-primary education increased from 5 percent to 40 percent in 2010 and 2014, respectively.

Evidence from both high-income countries and low- and middle-income countries suggests that preschool programs are beneficial beyond the initial years（e.g., Engle et al., 2011；Gür Tekin & Pınar, 2023；Ludwig & Phillips, 2008；Shafiq et al., 2018；Taniguchi, 2020）. However, most studies conducted in low- and middle-income countries have focused on exploring these benefits at only one（age 5 or 15）or only over a short term（between the ages of 5 and 8）（e.g., Taniguchi, 2020；Woldehanna, 2011；Woldehanna & Araya, 2017）. Further, Sosu and Pimenta（2023）found the different magnitude of benefits from preschool programs by family socioeconomic status groups, but little evidence exists on the moderating role of family socioeconomic status on the relationship between preschool attendance and academic achievements（e.g., Shafiq et al., 2018；Woldehanna, 2016）. Therefore, research gaps exist regarding the long-term effects of preschool participation on later children's academic achievements and the

moderating role of family socioeconomic status.

   This study aims to investigate the long-term effects of preschool participation on children's academic achievements at ages 12 and 15 and to explore the moderating role of family socio-economic status. Following the objectives, two research questions were set: (i) To what extent does preschool participation associated with children's vocabulary, reading, and math achievements across years? (ii) To what extent is the association of preschool with children's academic achievements moderated by family socioeconomic status?

   The significance of the study lies in its estimation of the long-term effects of preschool participation on academic achievements and the role of family socioeconomic status as a moderating factor. Despite substantial evidence on the short-term benefits of preschool participation on academic achievements, there are notable research gaps regarding the persistence of these effects over time and the influence of family socioeconomic status. Addressing these gaps is crucial, as it provides insights into the enduring impact of preschool participation and its potential role in mitigating educational disparities.

2   Overview of Early Childhood Education and Learning Achievements in Ethiopia

2.1   Development of Early Childhood Education Sub-sector in Ethiopia

   The Government of Ethiopia (1994) acknowledged the importance of early childhood education in the Education and Training Policy, "kindergarten will focus on the all-round development of the child in preparation for formal schooling" (p.14). However, early childhood education in Ethiopia is not compulsory, as there are insufficient resources to provide basic primary and secondary education. The government could not explicitly budget for this subsector until the recent policy reform. Instead, the government encouraged private actors to invest in early childhood education (Hoot et al., 2004; Woldehanna & Araya, 2017).

   In 2010, the Early Childhood Care and Education (ECCE) policy framework was established at the interministerial level in cooperation with UNICEF and the Child-to-Child initiatives. The ECCE aims at accessible, equitable, and quality pre-primary education for all children under four pillars: parental education; health and early stimulation program from prenatal up to 3 years old; preschool community-based kindergarten from 4 to 6 years old; and community-based non-formal school readiness programs. The government has outlined a very ambitious plan in its Fifth Education Sector Development Plan (ESDP V) with a target of 80 percent gross enrolment rate through increasing the budget share of the subsector within general education from 3 percent in 2015/16 to 11 percent in 2019/20. Since its launch in 2011/12, the program

has significantly expanded pre-primary education access, increasing coverage from 5.3 percent to 48.6 percent in 2021/22 (Ministry of Education, 2023).

2.2 Schooling and Learning Achievements in Ethiopia

Despite the notable increase in the net primary and secondary school enrollment, recent evidence shows that getting children into school has not translated into human capital accumulation (Plavgo, 2021). For example, sub-Saharan Africa has the highest rates of learning poverty in the world, with 9 out of 10 children unable to read and understand a simple story by the age of 10.[2] Children affected by conflict or climate emergencies are at the epicenter of this educational crisis and face the highest learning poverty rates in the region. Over half of the world's crisis-affected children live in sub-Saharan Africa (UNICEF, 2023b).

Ethiopia has also made significant progress toward universal primary education, with a net enrollment of 88.7 percent in the 2021/22 school year. Shortcomings in the quantity of schooling and its quality explain a large part of the distance to the frontier. Furthermore, while the majority of children enroll in school, a significant number do not make adequate progress: Only 33.1 percent make it to secondary school. In Ethiopia, 13 million children (pre-primary, primary, and junior secondary) are out of school. An estimated 3.5 million additional children (primary and secondary) are at risk of dropping out of school. This evidence suggests that the school is inefficient and students are not learning adequately (UNICEF, 2023a).

Further, 90 percent of children in Ethiopia at a late primary age today are not proficient in reading, and 89 percent do not achieve below minimum proficiency at the end of primary school (World Bank, 2019). Plavgo (2021) found that family socioeconomic status determines educational trajectories even if children have the same initial cognitive abilities. More socioeconomically advantaged families are not sensitive to the level of children's cognitive abilities when deciding about their transition to upper primary school. However, previous studies have paid less attention to how family socioeconomic status moderates the effect of preschool participation on later academic achievement in Ethiopia.

3   Literature Review

3.1 The Effect of Preschool Participation: How Long Does the Effect Last?

The first argument concerning the effect of preschool participation is the heterogeneity across years (how long will the effect of preschool participation last?). Engle et al. (2011) systematically reviewed the short-term effect of early childhood education programs on school

readiness and later academic achievements in low- and lower-middle-income countries. It demonstrated that preschool children obtained higher cognitive development scores, numeracy-literacy skills, social-emotional development, psychological and behavioral outcomes, and educational attainment. Denham and Brown (2010) explained its mechanism by demonstrating that attending preschool helps children learn to interact with peers, follow instructions, and develop emotional self-regulation. In previous studies on the case of Ethiopia, Woldehanna (2011) found the short-term positive effects of preschool attendance for urban children on cognitive abilities at ages 5 and 8 using Young Lives Ethiopia, applying ordinary least square (OLS) regression analysis and instrumental variable (IV) estimation by using community dummies.

Besides, the long-term effects of preschool participation have been debated theoretically and empirically in previous literature. The cumulative model of human capital production developed by Cunha and Heckman (2007) highlighted the interactive nature of children's skill-building and investment by families, preschools, schools, and other agents. Additionally, they summarized human capital accumulation in their "skill begets skill" phase, demonstrating two distinct processes. The first is self-productivity, which suggests that the impacts of preschool interventions are particularly likely to persist when designed to build skills incrementally within developmental domains such as mathematics or literacy. The second set of processes is dynamic complementarity and substitutability (e.g., Ceci & Papierno, 2005; Heckman, 2006). Bailey et al. (2020) demonstrated these concepts in the following way: Children who have higher foundational skills will benefit more from preschool participation than children who have less foundational skills. The skills-building model features dynamic complementarity—the teaching investment complements a child's incoming level of foundational skills and produces a Matthew effect, where the rich get richer. The Abecedarian Project found that individuals who attended preschool had higher reading and math scores as adults (Campbell et al., 2002). If teaching investments are more productive for children with less foundational skills, it is conceptualized as the model, which features dynamic substitutability—the teaching investment is compensatory by raising skills already mastered. Several interventions for preschool children found significant short-term effects, but they have been found to fade over time (e.g., Clements et al., 2013; Deming, 2009; Smith et al., 2013)

Despite that, little attention has been devoted to understanding the long-term effect of preschool participation within low- and middle-income countries. Taniguchi (2020) examined the relationship between pre-primary education and reading achievement at age 15 in seven countries participating in the Programme for International Student Assessment (PISA) for Develop-

ment project. Taniguchi（2020）applied the OLS regression analysis and concluded that pre-primary education benefited Ecuador, Honduras, Senegal, and Zambia but had little impact on Cambodia, Ecuador, Guatemala, and Paraguay. Shafiq et al.（2018）examined the relationship between early childhood education participation and long-term outcomes, including labor market results, post-ECE educational achievement, and cognitive and socioemotional abilities in 12 countries：Armenia, Bolivia, Colombia, Georgia, Ghana, Kenya, Laos, Macedonia, Sri Lanka, Ukraine, Vietnam, and China（Yunnan Province only）. Shafiq et al.（2018）used OLS and propensity score matching in the analysis. Results showed conflicting evidence within countries but suggested long-term benefits across countries. In the case of Ethiopia, Woldehanna（2011）and Woldehanna and Araya（2017）examined the relationship between preschool attendance and secondary school completion, showing the positive effects on the secondary completion rate at age 15. Summarizing the previous studies, the long-term effect of preschool on later achievements depends on targeting countries and their context.

3. 2　The Effect of Preschool Participation：Who Will Benefit More From it?

The second debate on the effect of preschool participation is whether the magnitude of the benefit is different by group. In particular, previous literature has focused on the moderating role of family socioeconomic status（e.g., Bai et al., 2020；Burger, 2010；Sosu & Pimenta, 2023）. Sosu and Pimenta（2023）categorized different outcomes when examining early childhood education's impact on low socioeconomic status. The first is a compensatory effect, whereby children from lower socioeconomic households benefit more significantly from early childhood education attendance than those from high socioeconomic peers. Bai et al.（2020）found that students from economically disadvantaged backgrounds experience substantial benefits from early childhood education programs. The second is a leveraging or accumulated advantages effect, wherein the benefits of early childhood education attendance are more significant for those with higher socioeconomic status compared to peers of lower socioeconomic status. Belsky et al.（2006）examined the effect of Sure Start Local Programmes（SSLPs）on children and their families and found that the SSLPs seem to benefit those with greater personal resources and their children but seem to have an adverse effect on the most disadvantaged children. The third is an additive effect when the benefits of early childhood education attendance are similar for all children, regardless of socioeconomic status. Burger（2010）found that children from socioeconomically disadvantaged families received as much or slightly more benefit than their more advantaged peers.

Our literature review has not revealed any studies that have examined whether the effect of preschool participation on later academic achievements fades out or remains across years, primarily focusing on the differences in children's family socioeconomic status. These are the gaps that this study addresses in the current study. Understanding both the nature of the long-term effect of preschool participation and socioeconomic inequalities, as well as the moderating role of family socioeconomic status, is important. This is because reducing inequality depends on the extent to which preschool participation similarly affects the later academic achievements of children from high and low socioeconomic status.

4   Methodology

4. 1   Data and Sample

The study uses data from the Young Lives Project in Ethiopia for the empirical analysis.[3] This Young Lives Project is part of a longitudinal study of child poverty and inequality tracking 12,000 children in four low- and middle-income countries: Ethiopia, India, Peru, and Vietnam. In Ethiopia, Young Lives has followed 3,000 children since 2001. The data consists of two cohorts: the younger cohort born in 2001-02 and the older cohort born in 1994-95. Over the 20 years of the study, Young Lives has conducted five rounds of quantitative surveys. For the younger cohort, 1,999 children aged around one year were selected from 20 sentinel sites of the five major regions (Addis Ababa, Amhara, Oromia, Southern Nations, Nationalities and Peoples [SNNP], and Tigray) in Round 1 because 90 percent of the population lives in these areas. In Round 1 of the quantitative survey (2002), the younger cohort children were around one year old; in Round 2 (2005), around five years old; in Round 3 (2009), approximately eight years old; in Round 4 (2013-14) approximately 12-13 years old, and in Round 5 (2016), around 15 years old. The data collected in Rounds 2 to 5 include information on children and their families' access to key services, children's work, time-use patterns, social relationships, and core economic indicators such as assets. In addition, there are also data on children's nutritional status, cognitive and schooling outcomes, and subjective well-being. It is important to note that Young Lives oversamples low-income families to study the causes, consequences, and effects of poverty, and the results cannot be generalized to the whole population of the state (Woldehanna et al., 2018).

To investigate the effect of preschool participation on later academic achievements, we use the Young Lives data on the younger cohort in Ethiopia from rounds 2, 4, and 5 of the quantitative survey. Since the government set preschool programs for children ages 4 to 6, this study

Figure 1. Comparison of Academic Achievements between Preschool Participants and Non-participants
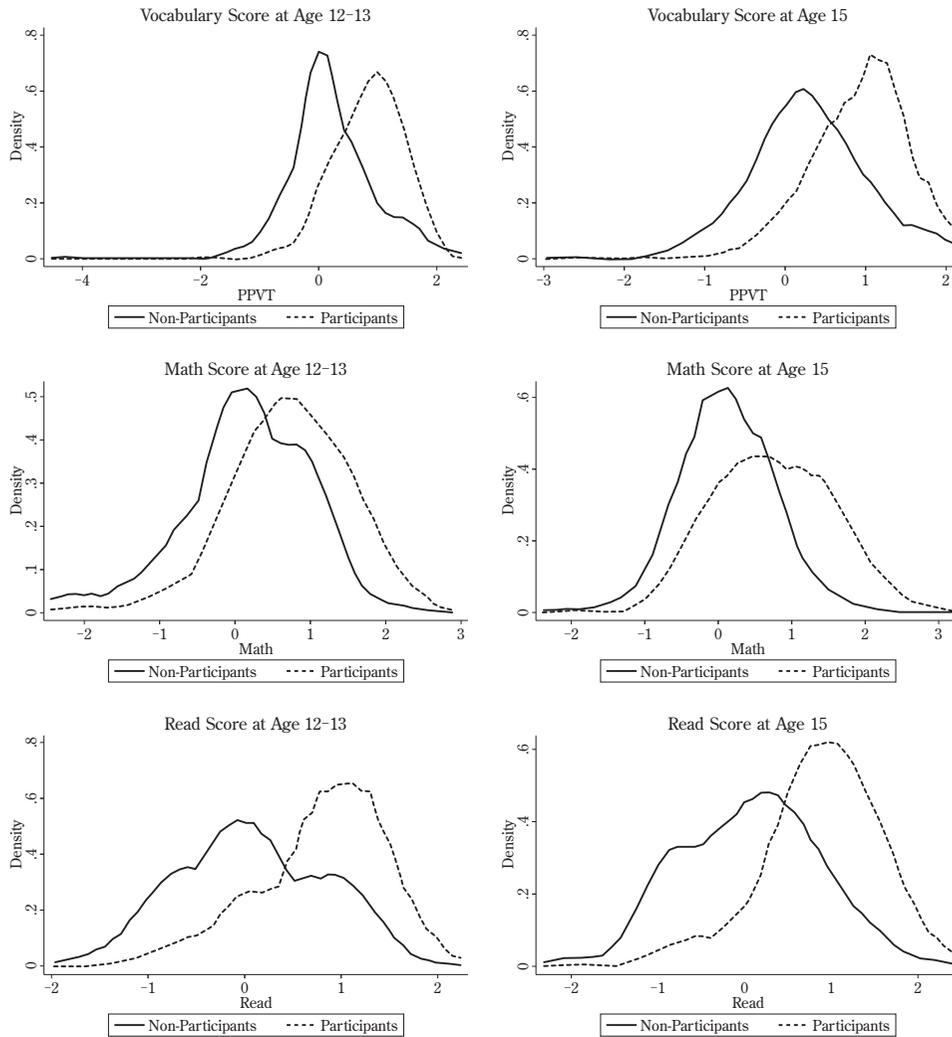
considers children who participated in preschool programs ages 4 to 6 as a treated group. The participation rate in preschool programs in rural areas is approximately 1 percent. This study utilized only samples of those who lived in urban areas at Round 2 in our analysis.

　This study uses several dependent variables to determine academic achievements. The Peabody Picture Vocabulary Test (PPVT) was used to indicate vocabulary. This is the only common test administered across rounds. Different tests were used to measure math and reading across rounds. The following dependent variables are used in our analysis: the PPVT to meas-

Table 1. Mean of Academic Achievement Test Scores of Children at Ages 12-13 and 15 by Selected Group

	Number of Samples	Vocabulary		Math		Read	
		Age 12-13	Age 15	Age 12-13	Age 15	Age 12-13	Age 15
All Samples	694	0.56	0.62	0.46	0.45	0.45	0.49
Preschool Participation							
Yes	371	0.85	0.90	0.73	0.75	0.78	0.88
No	323	0.23	0.29	0.16	0.12	0.07	0.05
Socioeconomic status							
1st quartile (Lowest)	176	0.16	0.23	0.11	0.13	0.17	0.16
2nd quartile	177	0.44	0.50	0.30	0.28	0.32	0.40
3rd quartile	174	0.73	0.73	0.67	0.57	0.55	0.57
4th quartile (Highest)	167	0.92	1.04	0.80	0.86	0.78	0.87
Region							
Addis Ababa	252	0.91	0.96	0.79	0.91	0.83	0.94
Amhara	84	0.61	0.66	0.53	0.39	0.59	0.77
Oromia	91	0.47	0.48	0.29	0.12	-0.06	0.03
SNNP	175	0.31	0.49	0.11	0.16	0.17	0.16
Tigray	92	0.10	0.02	0.35	0.16	0.33	0.11

Source: Calculated by the authors based on Young Lives Ethiopia (Rounds 2, 4, and 5)

Table 2: Summary Statistics of Independent Variables by Preschool Status

	All (n=694)				Non-Participants (n=323)				Participants (n=371)			
Variable	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Preschool Participation	0.53	0.50	0	1								
Socioeconomic status												
1st quartile (Lowest)	0.25	0.44	0	1	0.37	0.48	0	1	0.16	0.36	0	1
2nd quartile	0.26	0.44	0	1	0.26	0.44	0	1	0.25	0.43	0	1
3rd quartile	0.25	0.43	0	1	0.23	0.42	0	1	0.27	0.44	0	1
4th quartile (Highest)	0.24	0.43	0	1	0.14	0.35	0	1	0.33	0.47	0	1
Height for age	-1.18	1.11	-6.57	4.59	-1.35	1.17	-6.57	3.02	-1.03	1.02	-3.49	4.59
Siblings before	1.96	2.06	0	14	2.42	2.21	0	14	1.55	1.83	0	10
Siblings after	0.49	0.64	0	4	0.63	0.69	0	3	0.36	0.57	0	4
Region												
Addis Ababa	0.36	0.48	0	1	0.07	0.26	0	1	0.61	0.49	0	1
Amhara	0.12	0.33	0	1	0.03	0.16	0	1	0.20	0.40	0	1
Oromia	0.13	0.34	0	1	0.24	0.42	0	1	0.04	0.19	0	1
SNNP	0.25	0.43	0	1	0.39	0.49	0	1	0.13	0.34	0	1
Tigray	0.13	0.34	0	1	0.27	0.45	0	1	0.01	0.10	0	1

Source: Calculated by the authors based on Young Lives Ethiopia (Round 2)

ure vocabulary, math tests, and reading tests at Rounds 4 and 5, respectively. This study applied the item response theory (IRT) to academic achievements.[4] Unlike simpler alternatives, it does not assume that each item is equally difficult. The IRT treats the difficulty of each item as information to be incorporated in scaling items, which makes it helpful to have a more accurate measurement of academic achievements.

Figure 1 is the comparison of academic achievements between preschool participants and

non-preschool participants at the ages 12–13 and the age of 15. The figure shows the kernel density distribution of academic achievements for preschool participants and non-participants. The figure presents higher density in right-sided for preschool participants, indicating that children who participated in preschool obtained higher scores than those who did not. Further, Table 1 shows the mean of academic achievements for independent variables by selected group. The table indicates that children of high socioeconomic status and those from Addis Ababa have higher academic achievement scores.[5] Lastly, Table 2 shows the summary statistics of independent variables and compares independent variables between preschool and non-participants. These independent variables, representing family and child characteristics at age 5, were created using Round 2 data. More children from high socioeconomic status (e.g., 3rd and 4th quartile) are in the preschool participants group. The definitions of dependent and independent variables are shown in Appendix 1.

Regarding the data exclusion, 89 observations were excluded because those observations were not tracked until Round 5. The information was collected from 759 observations completed at all rounds. Then, 53 observations (7 percent) had missing data in dependent variables, and 12 samples (2 percent) had missing data in independent variables. So, those observations were excluded from the analysis. In short, 694 out of 759 samples (91.4 percent) remained in our analysis (see the Data Exclusion Chart in Appendix 2).

4.2 Analytical Model

This study uses an OLS regression analysis and estimates coefficients for each year as a cross-sectional model. Following Shafiq et al. (2018) and Sosu and Pimenta (2023), the OLS regression equation with the primary predictor variable, preschool participation, and control variables is given as follows:

$$Y_{i,age} = \beta_0 + \beta_1 Preschool_i + \beta_2 SES_i + \beta_3 X_i + u_i \tag{1}$$

Where $Y_{i,age}$ refers to the academic achievements of individual i at *age* (children at the age 12–13 or 15), β_0 is a constant, β_1 is a coefficient of *Preschool* dummy variable (whether a child participated in preschool from the age 4 to 6), β_2 is a coefficient of categorical variables of family socioeconomic status at the age 5, and β_3 is a coefficient of X_i consisting of control variables such as early childhood health status (*"Height for age"*) at the age 5, the number of elder siblings an individual i has at the age 5 (*"Older siblings"*), and the number of younger siblings an individual i has at the age 5 (*"Younger siblings"*). Although years of education or completed education level are among the influential factors in academic achievements, this study did not in-

clude them in the model. This is because years of education are determined after the participation in preschool and itself is an outcome variable in the model.[6]

To examine whether the associations between preschool participation and academic achievements are moderated by family socioeconomic status, equation (2) includes the interaction term between preschool participation and family socioeconomic status as the following equation:

$$Y_{i,age}=\beta_0+\beta_1 Preschool_i+\beta_2 SES_i+\beta_3 X_i+\beta_4 Preschool*SES_i+u_i \qquad (2)$$

Where a moderator is family socioeconomic status (SES). A moderator is a third variable that changes the relation between a predictor (X) and an outcome (Y), thereby affecting the strength and/or direction of the relation between the two variables. As shown in equation (2), the moderator is family socioeconomic status, which could interact with the primary predictor variable (i.e., preschool participation) to influence the outcome (i.e., academic achievements), such that any effects of the primary predictor on the dependent variable are conditional on, or dependent on, values of the moderator (see Fairchild & McQuillin, 2010). In the regression analysis, this dependency results in several bivariate regression lines that forecast the dependent variable (Y) from the independent variable (X), varying according to the different values of the moderator variable Z. The scree plots will be shown, followed by the result tables. It should be noted that the main effects are no longer additive and need to be interpreted with reference to the moderator variables, as the simultaneous effect of the variables influences the outcome variables.

5   Results

Table 3 presents the preschool coefficients and standard errors obtained from OLS regressions across years (at ages 12-13 and 15). Strong statistical evidence shows preschool participation is positively associated with later academic achievements. Columns 1-2 indicate that children who participated in preschool obtain significantly higher vocabulary scores at ages 12-13 and 15, with a 95 percent confidence level. In the same way, Columns 3-4 and 5-6 indicate the positive influence of preschool participation on math and reading scores at ages 12-13 and 15, respectively. Some control variables are also significantly associated with academic achievements. For example, family socioeconomic status positively correlates with vocabulary, math, and reading scores. Children from high socioeconomic status are more likely to achieve better academic achievements. Estimated coefficients of siblings composition such as "*Elder siblings*" and "*Younger Siblings*" indicate that the number of siblings is negatively correlated with aca-

Table 3: OLS Regression Analysis of Academic Achievements

	Vocabulary		Math		Read	
	Age 12–13	Age 15	Age 12–13	Age 15	Age 12–13	Age 15
Preschool Participation	0.308**	0.246**	0.343*	0.249**	0.479***	0.408**
	(0.08)	(0.07)	(0.11)	(0.05)	(0.08)	(0.11)
Socioeconomic status (Ref: 1st quartile)						
2nd quarter	0.128**	0.149*	0.0497	0.00918	0.00806	0.0879
	(0.04)	(0.06)	(0.08)	(0.08)	(0.11)	(0.07)
3rd quarter	0.361**	0.306***	0.405***	0.255*	0.231**	0.221**
	(0.07)	(0.05)	(0.06)	(0.08)	(0.07)	(0.06)
4th quarter (Highest)	0.479***	0.556***	0.442***	0.457**	0.320**	0.407***
	(0.09)	(0.07)	(0.06)	(0.12)	(0.09)	(0.06)
Health and Nutritional Status at Age 5						
Height for age	0.0224	0.0258	0.0289	0.0200	0.0339	0.000250
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Siblings before	−0.0222*	−0.0118	−0.0292**	−0.0148	−0.0172	−0.0395**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Siblings after	−0.0770*	−0.0793	0.0226	0.00144	−0.000994	−0.0536
	(0.03)	(0.05)	(0.03)	(0.06)	(0.05)	(0.06)
Region (Ref: Addis Ababa)						
Amhara	−0.140*	−0.139***	−0.0957	−0.381***	−0.123	−0.0334
	(0.05)	(0.02)	(0.11)	(0.05)	(0.07)	(0.04)
Oromia	−0.145	−0.227*	−0.198	−0.544***	−0.497**	−0.530***
	(0.10)	(0.07)	(0.17)	(0.04)	(0.12)	(0.07)
SNNP	−0.272**	−0.184***	−0.350	−0.496***	−0.287	−0.401
	(0.06)	(0.02)	(0.16)	(0.04)	(0.13)	(0.19)
Tigray	−0.346**	−0.537***	0.0321	−0.382***	0.0391	−0.315**
	(0.09)	(0.04)	(0.18)	(0.08)	(0.13)	(0.09)
Constant	0.412**	0.496***	0.260	0.490**	0.280	0.420*
	(0.08)	(0.06)	(0.18)	(0.12)	(0.13)	(0.15)
R-square	0.296	0.304	0.199	0.281	0.280	0.316
Observations	694	694	694	694	694	694

Source: Created by the authors based on Young Lives Ethiopia (Rounds 2, 4, and 5)

Note: Robust standard errors clustered at the primary sampling unit are in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

demic achievements. The estimated results of the categorical variable of regions indicate that children who live outside of Addis Ababa are likely to get lower scores than those who live in Addis Ababa.

Table 4 shows the estimated results with interaction terms between preschool participation and socioeconomic status. Except for math scores, preschool participation is significantly and positively associated with academic achievements at ages 12–13 and 15. The main effect of family socioeconomic status varies, depending on the age and subjects of academic achievements. Overall, family socioeconomic status has no moderating effect on the association between pre-

Table 4: OLS Regression Analysis of Academic Achievements with Interaction Terms

|	Vocabulary		Math		Read	
	Age 12–13	Age 15	Age 12–13	Age 15	Age 12–13	Age 15
Preschool Participation	0.338*	0.446**	0.378	0.00480	0.433*	0.382*
	(0.11)	(0.09)	(0.17)	(0.11)	(0.15)	(0.12)
Socioeconomic status (Ref: 1st quartile)						
2nd quartile	0.117*	0.194	0.137	−0.00308	0.0506	0.165
	(0.04)	(0.09)	(0.10)	(0.07)	(0.07)	(0.08)
3rd quartile	0.412**	0.436***	0.394***	0.116	0.170	0.175*
	(0.10)	(0.08)	(0.06)	(0.06)	(0.08)	(0.08)
4th quartile (Highest)	0.476*	0.710***	0.404**	0.174	0.256	0.310*
	(0.18)	(0.12)	(0.11)	(0.14)	(0.13)	(0.10)
PreschoolParticipation*SES (Ref: Preschool*SES1st)						
Preschool Participation*SES2nd	0.0130	−0.148	−0.180	0.100	−0.0693	−0.141
	(0.08)	(0.11)	(0.17)	(0.18)	(0.18)	(0.17)
PreschoolParticipation*SES3rd	−0.100	−0.304*	0.00614	0.339	0.124	0.0906
	(0.10)	(0.12)	(0.13)	(0.16)	(0.10)	(0.11)
PreschoolParticipation*SES4th	−0.00933	−0.312	0.0329	0.513*	0.109	0.144
	(0.17)	(0.14)	(0.19)	(0.19)	(0.10)	(0.13)
Health and Nutritional Status at Age 5						
Height for age	0.0206	0.0206	0.0278	0.0248	0.0354	0.000546
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)
Elder siblings	−0.0221*	−0.0124	−0.0295**	−0.0142	−0.0172	−0.0396**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Younger siblings	−0.0770*	−0.0763	0.0269	0.000370	0.000648	−0.0500
	(0.03)	(0.05)	(0.03)	(0.06)	(0.05)	(0.05)
Region (Ref: Addis Ababa)						
Amhara	−0.149*	−0.180***	−0.0901	−0.325***	−0.105	−0.0152
	(0.05)	(0.03)	(0.10)	(0.05)	(0.06)	(0.04)
Oromia	−0.146	−0.238**	−0.206	−0.534***	−0.498**	−0.535***
	(0.09)	(0.07)	(0.16)	(0.05)	(0.11)	(0.07)
SNNP	−0.268**	−0.167***	−0.357	−0.524***	−0.297*	−0.415
	(0.07)	(0.03)	(0.16)	(0.05)	(0.12)	(0.19)
Tigray	−0.339**	−0.532***	0.0198	−0.389**	0.0281	−0.329**
	(0.10)	(0.05)	(0.18)	(0.08)	(0.12)	(0.09)
Constant	0.398**	0.420***	0.249	0.579***	0.299	0.432*
	(0.10)	(0.07)	(0.20)	(0.10)	(0.15)	(0.15)
R-square	0.297	0.311	0.201	0.294	0.283	0.320
Observations	694	694	694	694	694	694

Source: Created by the authors based on Young Lives Ethiopia (Rounds 2, 4, and 5)
Note: Robust standard errors clustered at the primary sampling unit are in parentheses, *** $p < 0.01$, ** $p < 0.05$,
* $p < 0.1$

school participation and academic achievements. Figure 2 is the scree plots for the interaction terms and outcome variables, visualizing the moderating effect. As shown in Table 4 and Figure 2, the association of preschool participation with vocabulary scores at age 15 seems stronger for low socioeconomic status, while the association with math scores at age 15 is stronger for

Figure 2: Scree Plots for the Interaction Terms between Preschool Participation*SES and Academic
　　　　　　Achievements
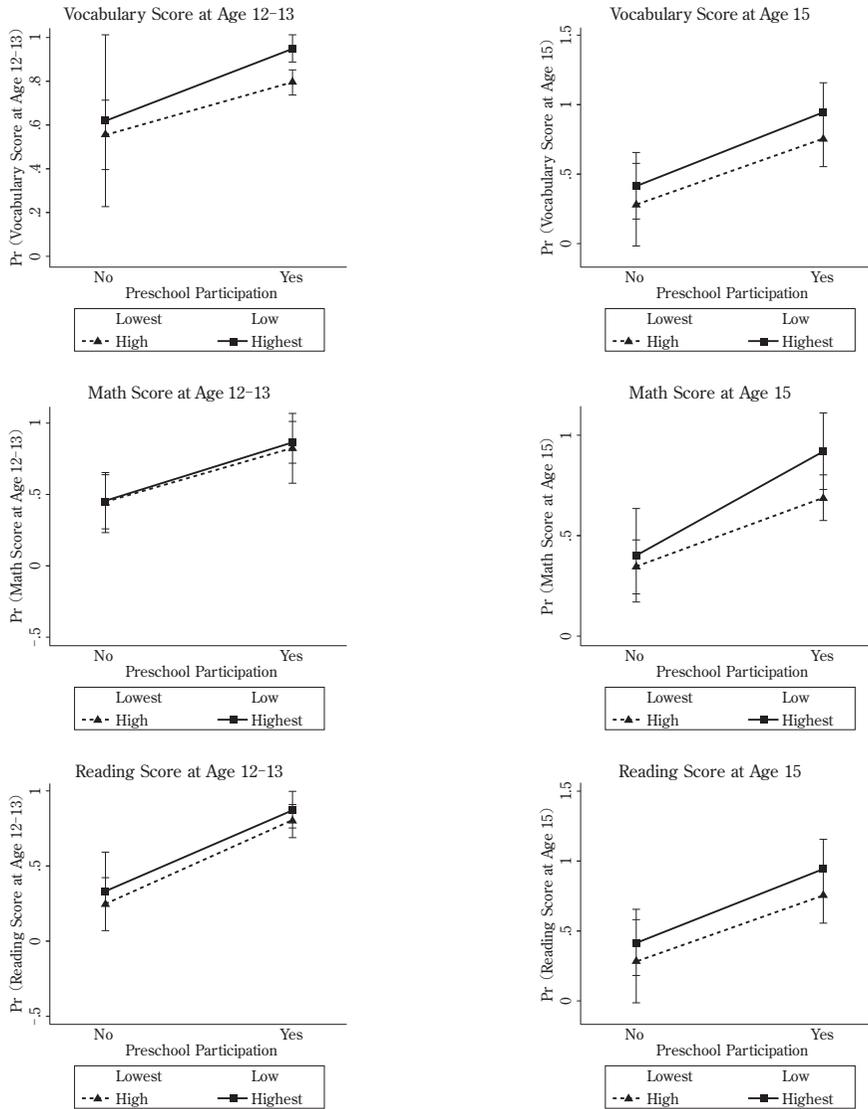
children of high socioeconomic status.

6　Discussion

This study investigated the long-term effect of preschool participation on later academic

achievements and the moderating role of family socioeconomic status on the association between preschool participation and academic achievements. Our primary analysis found preschool participation positively associated with vocabulary, math, and reading scores at ages 12–13 and 15. This finding is consistent with previous studies conducted in high-income countries such as the Abecedarian, Perry, and Nurse-Family Partnership Programs (e.g., Campbell et al., 2012; Heckman, 2011). The other studies in low- and middle-income countries found mixed results on the long-term effect of preschool participation on later academic achievements (e.g., Taniguchi, 2020; Shafiq et al., 2018). Shafiq et al. (2018) showed a strong positive association between participation in early childhood education and literacy proficiency. Taniguchi (2020) found that attending preschool positively associated with reading achievements at age 15 in three countries (Honduras, Senegal, and Zambia), with negligible effects in Cambodia, Ecuador, Guatemala, and Paraguay. In the case of Ethiopia, Woldehanna (2016) shows that the positive effects on cognitive performance at age 5 persisted at the 8. Later, using the Young Lives Project data, Woldehanna and Araya (2017) found a positive association between preschool participation and secondary completion rate at age 15. This study attempted to fill the research gap on how long the effect on academic achievements lasts in the case of Ethiopia. The estimated results showed that preschool participation positively influences later academic achievements until age 15. This could be one of the explanations for the findings of Woldehanna and Araya (2017). In short, this study contributes to the explanation and the link between the results of Woldehanna (2016) and Wolehanna and Araya (2017). The study demonstrates that participation in preschool programs promotes children's academic performance at primary school and increases the probability of completing secondary school at 15.

Our findings are consistent with the hypothesis of the skills-building model, which features dynamic complementarity, suggesting that children who enter school with high academic achievements will profit most from primary and secondary schooling. At the same time, the estimated results did not support the second hypothesis of dynamic substitutability, which is a genuine possibility (Jenkins et al., 2016; Rossin-Slater & Wust, 2020).

We discuss our findings based on the skills-building model developed by Cunha and Heckman (2007) and consider their reasons. Abenavoli (2019) systematically reviewed whether and how early childhood education programs sustained impacts by introducing the terms "fade-out," "catch up," and "convergence." They cautioned the term fade-out because this does not necessarily mean that knowledge and skills children acquired during the program necessarily lost (or faded) over time. Instead, they demonstrated two processes of the disappearing effect.

First, the growth trajectory among early childhood education program participants is character-ized by increases in the outcome level during the preschool years followed by decreases after kindergarten entry, whereas non-participants show relatively steady levels over time. Thus, ear-lier gains appear to decay among program participants; second, the outcome level increases over time among early childhood education program attendees and non-attendees; previously acquired skills do not decay for either group.

Nonetheless, the learning rate among early childhood education attendees decreases begin-ning in kindergarten after showing acceleration relative to non-attendees during the early child-hood education year. Non-attendees show slower growth before kindergarten, but their pace of learning picks up following the transition to school, resulting in their "catch-up" (Barnett, 2011). According to our results and previous studies, the effect of participation in preschool programs has persisted at least by the age of 15 in terms of academic achievements, suggesting that these mechanisms (e.g., catch-up and convergence) demonstrated by Abenavoli (2019) have not occurred in these countries. In other words, the gap in academic achievements before primary school entry most likely determines later academic achievements, even at age 15. These results and discussions suggest that investment in preschool programs is critical for stu-dents' learning and skill development, especially in low- and middle-income countries, where the phenomenon of catch-up and convergence are less likely to occur.

In the second analysis, we estimated the moderating role of family socioeconomic status on the association between preschool participation and later academic achievements. The results revealed that there were no moderating effects of family socioeconomic status. Overall, the as-sociation between preschool participation and later academic achievements did not significantly change regardless of the children's family socioeconomic status. Exceptionally, the preschool-academic-math score association was stronger for high socioeconomic children, and the pre-school-reading score was stronger for low socioeconomic peers. Previous studies examining the short-term effect (e.g., school readiness) of early childhood education found that the bene-fits of early childhood education for school readiness seem to be higher for children of high socioeconomic status compared to peers of low socioeconomic status (e.g., Belsky et al., 2006; Sosu & Pimenta, 2023). These studies suggested a predominantly leveraging effect, which is inconsistent with our findings. Previously demonstrated that differences in the quantity or qual-ity of programs accessed by children from high and low socioeconomic status backgrounds will lead to a stronger association between early childhood education and readiness for children from high rather than low socioeconomic status backgrounds (e.g., McCoy et al., 2018). Ac-

cording to Young Lives Ethiopia, at round 2, most children participated in private preschool programs, and government preschool was not so popular in Ethiopia. Around 70 percent of children participated in primary preschool, while the rest participated in government preschool programs. This might be related to relatively small disparities in the quality of preschool programs at that time, leading to the no moderating role of family socioeconomic status.

We must acknowledge several limitations and the scope of further research. First, a generalizability of the results. The sample, drawn from urban areas, may differ from Ethiopia's rural areas regarding the quality of preschool programs and accessibility. The current preschool program might be changed due to the government's significant efforts to increase access to preschool in rural and urban areas. Second, indicators of preschool quality were not included in the economic model due to the data limitation. Identifying the conditions under which preschool programs might exacerbate socioeconomic inequalities or serve as an equalizer for children's academic achievements from the long-term perspective would be valuable. Lastly, the primary concern with using OLS in this study is the potential endogeneity of the variable of interest, specifically parental decisions to send their children to school. This endogeneity arises from both observable and unobservable factors influencing these decisions. Future research should focus on identifying instrumental variables, utilizing longer-term longitudinal data, and considering experimental designs to address endogeneity more effectively.

7   Conclusion

This study examined the long-term effect of preschool participation on children's academic achievements and the moderating role of family socioeconomic status. It used data from the younger cohort of Young Lives Ethiopia, which is a panel data that tracked children for over 15 years. Vocabulary, math, and reading scores were used to measure academic achievements. This study applied the OLS to estimate the effect of preschool participation on later academic achievements and added the interaction term in the second analysis. The estimated results show preschool participation and family socioeconomic status positively correlate with later academic achievements. The findings are consistent with previous empirical studies in low- and middle-income countries. Theoretically, this result supports the hypothesis of dynamic complementarity（persisted effects）in the skills-building model. It indicates that the differences in academic performance at an early age will remain until adolescence. This is because the mechanisms such as catch-up and convergence may not occur in Ethiopia. Our findings provide strong evidence for the importance of participating in preschool programs；the early gap in aca-

demic achievements before primary school entry will most likely determine later academic achievements.

We found that overall, family socioeconomic status had no moderating role in the association between preschool participation and academic performance. Nevertheless, the preschool-math score association was stronger for high socioeconomic children, and the preschool-reading score was stronger for low socioeconomic peers. Our findings of the second analysis suggest that investment in preschool programs is critical for human capital accumulation in low and high socioeconomic backgrounds. However, no strong evidence exists that preschool participation decreases or increases the socioeconomic status gap for later academic achievements.

Appendix

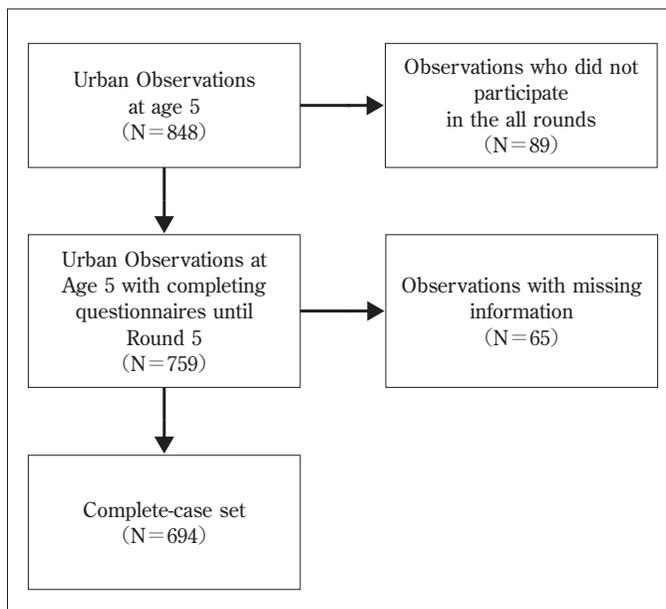Appendix 1   Description of Dependent and Independent Variables

Neme of Variables	Value	Definition
Dependent Variables: Academic Achievements		
Vovabulary	Coutinuous	Percentage of corrected answers in Peabody Picture Vocabulary Test (PPVT). After round 4 and 5, items with high guessing parameter or xero variation were excluded (in detals, see Leon (2020).
Math	Coutinuous	The maths achievement tests where different in each round. A set of common items were kept across rounds and age cohorts that allows to equate maths scores across rounds and cohorts.
Reading	Coutinuous	The items included in the assessments measure are reading literacy, from basic decoding to identifying underlying ideas from a narrative. A set of common items were kept across age cohorts and rounds in order to equate the reading comprehension scores.
Independent Variables: Covariates		
Father's and Mother's Education		
No education	Dummy	If child's father/mother does not have an education
Primary Level	Dummy	If child's father/mother education is from Grades 1–8
Secondary or above	Dummy	If child's father/mother is with Grade 9 or above
Socioeconomic status	Categorical	Wealthe index is a sum of the housing quality index (e.g., wall, roof, and floor materials), consumer durables index (e.g., posession of radio, motor bike, car, phone, tv, etc.), and services quality index (e.g., resources of drinking water, type of toilet, and cooking fuel)*
Siblings before	Continous	The number of children who was born before the child at age 5
Siblings after	Continous	The number of children who was born after the child at age 5
Z scores (height for age)	Continous	Proxy for nutritional status or health**
Preschool participation	Dummy	If a child participates in preschool programs at age 4 to 6
Addis Ababa	Dummy	If a child lives in this region at age 5
Amhara	Dummy	If a child lives in this region at age 5
Promia	Dummy	If a child lives in this region at age 5
SNNP	Dummy	If a child lives in this region at age 5
Tigray	Dummy	If a child lives in this region at age 5

* After the calculation, the index was divided into four groups

** An index used to assess how a child's height compares to the expected height of a healthy child of the same age and sex based on the 2006 WHO Child Growth Standards

Source: Created by the authors

Appendix 2. Data Exclusion Chart


```
┌─────────────────────────┐        ┌─────────────────────────┐
│   Urban Observations    │───────▶│ Observations who did not│
│       at age 5          │        │      participate        │
│      (N＝848)           │        │    in the all rounds    │
│                         │        │       (N＝89)           │
└─────────────────────────┘        └─────────────────────────┘
            │
            ▼
┌─────────────────────────┐        ┌─────────────────────────┐
│  Urban Observations at  │───────▶│ Observations with missing│
│  Age 5 with completing  │        │       information        │
│  questionnaires until   │        │        (N＝65)          │
│       Round 5           │        │                         │
│      (N＝759)           │        │                         │
└─────────────────────────┘        └─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│    Complete-case set    │
│      (N＝694)           │
└─────────────────────────┘
```

Source: Created by the authors

Notes

1) This study's term of early childhood education includes various early childhood programs such as preschool, kindergarten, and early childhood education programs, following Shafiq et al. (2018).

2) Learning poverty means being unable to read and understand a short, age-appropriate text by age 10. All foundational skills are essential, but we focus on reading because (i) reading proficiency is an easily understood measure of learning, (ii) reading is a student's gateway to learning in every other area, and (iii) reading proficiency can serve as a proxy for foundational learning in other subjects, in the same way, that the absence of child stunting is a marker of healthy early childhood development.

3) Young Lives Ethiopia is a major international study of childhood poverty led by the University of Oxford in partnership with Pankhurst Development and Research Consulting, led by Country Director Alula Pankhurst. The datasets are publicly open and can be found on the following website. https://www.younglives-ethiopia.org/ (Accessed July 13, 2022)

4) Item response theory has several uses in making and scoring tests. It is useful for producing scaled scores – scores that consider the differences in the difficulty of the items on different test forms (see Livingston, 2020). Since the questionnaire consists of binary answers, one-parameter logistic models were used in this study. Using IRT enables us to transform the retrieved results to mean 0 and a given standard deviation.

5) The author estimated family socioeconomic status by conducting a principal component analysis

based on family wealth and parental education. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.7460.

6) Years of education or completed grades can be categorized as bad control, which should not be included in a regression model even when its inclusion might be expected to change the short regression coefficients (in detail, see Angrist & Pischke, 2009)

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