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Child Development, Parental Investments, and School Environment: Evidence from Rural Thailand

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Abstract

This study investigates how child skills, parental investments, and the school environment influence early childhood development in the context of rural Thailand. Using data from the Reducing Inequality through Early Childhood Education (RIECE) program, our findings suggest that a child's lagged cognitive ability leads to improved language (expressive and receptive) and gross motor skills. Relating to parental investments, time investment is important for fine motor skills, receptive language, and personal-social skills. In contrast, material investment is only significantly linked to improvements in expressive language. Schooling intervention through the RIECE curriculum improved gross motor skills as well as expressive and receptive language skills. Finally, teacher experience led to better fine motor skills, while a higher student-teacher ratio improved expressive language skills. Our findings are heterogeneous across child genders.

Keywords: child development, cognitive, noncognitive, motor, cross-lagged, time investment, material investment, school environment, curriculum intervention.

1. Introduction

Human capital production at an early age has been receiving increased attention due to its role in short- and long-term outcomes. Early childhood skills complement future skills both within and across skill dimensions in both the short-term, observed as higher mathematics, reading, vocabulary, and socio-emotional skills (Bailey et al., 2020; Burns et al., 2022; Dulay et al., 2021; Slot et al., 2020), as well as the long-term, manifested as lower crime rates, lower teen pregnancy rates, and higher education and income (Campbell et al., 2010; García et al., 2016; Heckman & Masterov, 2007). Therefore, it is important to investigate key early childhood development inputs to inform investments and interventions at an early age.

The three layers of factors that affect early childhood development include children's characteristics, family environment, and school environment. Child's characteristics, such as age, gender, birth weight, height, and birth circumstances, are found to be significantly related to children's development in various fields (Allotey et al., 2018; Bornstein et al., 2016; du Toit et al., 2021; Hilaire et al., 2021). Child's lagged outcomes are also shown to predict later outcomes. In this regard, in the context of the United States, Guo et al. (2015) revealed that preschool reading ability predicted 1st-grade behavioral engagement, and 3rd-grade reading ability predicted 5th-grade behavioral engagement. In the same context, Zhang et al. (2023) found that cognitive flexibility and math achievements were reciprocally correlated from grades 2 to 5, and working memory and math achievement were reciprocally correlated from kindergarten to grade 5.

Family environments—particularly early parental investments—have a significant role in determining child development because they lay the foundation for the development of skills later in life and improve the productivity of investments farther down the line through dynamic complementarity (Francesconi & Heckman, 2016). Attanasio et al. (2020) found that parents' material investments, such as food, medications, educational goods, and clothing, significantly predicted children's health and cognitive abilities in India. In a study conducted in the United Kingdom, Del Bono et al. (2016) found that maternal time inputs in both educational and recreational activities improved their young children's verbal and emotional skills. Similarly, in the context of China, Wang et al. (2022) found that parental time investment, including reading, telling stories, singing, and playing with the child, was significantly positively related to the child's cognitive and social-emotional outcomes. In particular, the study found that greater investment in these areas was linked with a higher likelihood for the children to reach their developmental potential (or lower likelihood of developmental delays) compared to children with less of such an investment. Other family environment factors that have recently received increased attention include parenting style (Faizi & Kilenthong, 2022) and parents' characteristics (Mahardika & Sulistyaningrum, 2022).

In the broader social environment of the children, schooling is a key input to children's cognitive, noncognitive, and physical development (Anderson et al., 2003). A high-quality schooling environment that involves higher teacher quality (Hatfield et al., 2016), smaller classes (Krueger, 2003), and lower student-teacher ratios (Schwartz et al., 2012) can encourage and improve a child's educational attainment and future income. Furthermore, various educational interventions have also proven to be effective in early childhood educational development (Chujan & Kilenthong, 2021; García et al., 2016; Navarro-Patón et al., 2021). One such influential project is the Perry Preschool Project conducted from 1962 to 1967 in the US, which led to the establishment of the HighScope Education

Research Foundation and an early childhood program designed to improve school outcomes of preschool children from poor households. The literature has documented the wide-ranging and long-lasting impact of the Perry preschool project on early childhood education (Heckman et al., 2010).

Although early childhood development is essential for children's lifelong outcomes, hundreds of millions of children worldwide struggle to reach their full developmental potential, which may be attributed to the environment in which they grow up (Naudeau et al., 2012). Compared to urban areas, access to resources for children's development is limited in rural areas (Neuman & Devercelli, 2012), which may result in a gap in the early childhood development of rural and urban children (S. Guo et al., 2021). For instance, Zablotsky et al. (2019) found that children with a rural US residence were significantly more likely to suffer from developmental disabilities as compared to their urban counterparts. However, despite the abundance of recent literature on early childhood development, there are still few studies on factors that affect the early development of rural children beyond the children, family, and teachers' characteristics and schooling environment (S. Guo et al., 2021). The present study contributes to this narrow literature by investigating the impact of the three layers of factors discussed above on children's early development in rural Thailand.

This paper uses data from the Reducing Inequality through Early Childhood Education (RIECE) program that aims to improve the quality of early childhood education in Thailand by developing an innovative curriculum called the RIECE curriculum. This program was officially launched in May 2015 and covers 50 childcare centers in 26 subdistricts of the Mahasarakham and Kalasin provinces. Most of these centers have two levels of classes, one for 2 to 3 years old and the other for 3 to 4 years old. This type of public childcare center is available free of charge and easily accessible for poor households; therefore, most children in rural Thailand have been enrolled in these centers. In this dataset, child development, which is measured from the Developmental Surveillance and Promotion Manual (DSPM), developed by the National Institute of Child Health, Department of Health, Ministry of Public Health of Thailand, includes five domains: gross motor, fine motor, receptive language, expressive language, and personal-social skills. The lagged outcomes are parent reports based on the Denver Developmental Screening Test, which includes behavioral, cognitive, motor, and self-regulation skills. Parental investment includes both time and material. The schooling environment includes teacher's experience and gender, student-teacher ratio, and the RIECE curriculum intervention. This RIECE curriculum intervention is based primarily on the HighScope program. As mentioned above, the HighScope program was established following the Perry Preschool project. This program aimed to support children's cognitive and socioemotional development through active learning. Although this program has been successful in the US, there is a question of whether this program can be replicated in developing countries (Chujan & Kilenthong, 2021). An attempt to answer this question in the context of rural Thailand is the second contribution of this study.

In the following, section 2 reports data source and variable measurements, section 3 presents the empirical strategy employed, followed by estimation results and discussion in section 4. Finally, the research is concluded in section 5.

2. Data and Variable Measurements

2.1 Data

The data for this study came from the Reducing Inequality through Early Childhood Education (RIECE) program, which aims to improve the quality of early childhood education in rural Thailand by developing an innovative curriculum called the RIECE curriculum. This program was officially launched in May 2015 and covers 50 childcare centers in 26 subdistricts of Mahasarakham and Kalasin provinces. Most of these centers have two levels of classes, one for 2 to 3 years old and the other for 3 to 4 years old. RIECE data includes information on both children and households, in addition to school intervention data. The questionnaire is divided into three sections: teachers, households, and children. The household questionnaire focuses on socioeconomic status, covering household demographics of occupations, labor supply, and leisure for each household member, and household assets of income, expenditure, borrowing, and lending. The Denver Developmental Screening Test, National Educational Panel Study, World Health Organisation Quality of Life, Early Childhood Longitudinal Programme, and Cohort Study of Thai Children were used to design the children questionnaire. The children questionnaire includes basic information about the children in the household (e.g., age, gender, birth weight, child's health, chronic diseases, disability status, and educational attainment), as well as early childhood investments such as time and material inputs, parenting style, and nutritional inputs. Note that the designated respondents for the children's questionnaire were their main caregivers. If a family has more than one child, the main caregiver will be questioned about each child separately.

In 2015, a survey was conducted (before the new curriculum's implementation) in April and completed in October. The baseline dataset included 1,105 children from 1,054 households. However, child outcomes were tested for only 735 since the evaluators could not test all of the children due to the school year ending in early March, and testing at their homes was too problematic due to potential parent disruption. Added to the fact that some observations were missing information for our key variables, the final sample included 630 children.

2.2 Tested Child Outcomes Measurement

The dependent variable of this study uses the Developmental Surveillance and Promotion Manual (DSPM), developed by the National Institute of Child Health, Department of Health, Ministry of Public Health of Thailand. The DSPM is divided into five main skill domains: gross motor (with 24 questions including jumping, walking, balancing, etc.), fine motor (with 25 questions including cutting a piece of paper with certain precision, assembling parts of a cutout picture, holding a pencil correctly, etc.), receptive language (with 22 questions including identifying the size of the objects, selecting day and night in the pictures, choosing 8 colors based on their order, etc.), expressive language (with 22 questions including speak at least 3 consecutive words, have a reasonable response to a question, and take turns talking in a group, etc.), and personal and social skills (with 23 questions including cleans himself after defecating, playing the role of an adult, etc.). Note that the aggregate of these five skills was also considered a dependent variable of interest. See the online appendix for details of DSPM.

The DSPM is designed for children up to the age of five and is divided into 19 age groups, with several test items for each domain. A child is tested within their age range, passing if all items are completed successfully and failing if even one is missed, indicating delayed development. The original DSPM testing was expanded to include test items from two age ranges above and below the child's age to increase statistical power. If children pass their age range, they are tested one level higher; if they fail, they are tested one level below. Testing is limited to two levels above or below the children's age range to save time. This study's key measure of child development, the developmental score, is determined by the median of the children's highest age range. See the online appendix for sample questions for this test.

2.2 Lagged Child Outcomes Measurement

In assessing lagged child development outcomes, parent reports were utilized based on the Denver Developmental Screening Test. The child's development was evaluated through a direct interview with the main caregiver, focusing on the abilities or behaviors observed over the previous 12 months. This test consists of 29 items, with answers categorized into four frequency scales: usually, sometimes, unable, and never. For the purposes of this study, these scales were converted into numerical scores for the child: 5 for 'usually', 3 for 'sometimes', and 0 for 'unable' or 'never', thus a higher skill denoting greater abilities. Furthermore, these questions were mapped into four dimensions: behavioral (with 8 questions including the child having good relations with his friends, the ability to express anxiety, fear, likes and dislikes, etc.), cognitive (with 9 questions including explaining locations, ability to tell when needs to defecate or urinate, etc.), motor (with 6 including the child's ability to walk up the stairs, handle a pencil, pour water from a bottle, brush own teeth, etc.), and self-regulation skills (with 6 questions relating to the child following simple rules, ability to listen to a story or book for at least 5 minutes, playing with a toy for at least 5 minutes, etc.). Then, exploratory factor analysis (EFA), as in Cunha and Heckman (2008), was used to form a single index per skill. The confirmatory factor analysis process was conducted as per Gorsuch (1983). See the online appendix for all items relating to each dimension and the corresponding EFA results.

2.3 Lagged Parental Investments Measurement

Parental investment information came from the children's questionnaire and was collected by the main caregiver, which can be divided into two primary categories: time and material investment. Time investment refers to the hours the main caregiver spent engaging in various activities with the child in the past week. These activities include both recreational (e.g., drawing, sport, singing, dancing, or playing music) and educational activities (e.g., sorting, numbers, assembly block, reading books to the child, telling stories to the child (without a book), taking the child to a library, etc.). Material investment encompasses the presence of toys, such as blocks or LEGO, jigsaw puzzles, plastic or wooden toys, clay, sand, plasticine, sculptor's flour, and coloring books. It also includes the number of children's storybooks, picture books or picture cards, and readiness preparation exercises for children. Finally, time and material investments were extracted using the EFA process, as in the case of lagged child outcomes. See the online appendix for all items relating to time and material investments and the corresponding EFA results.

2.4 Schooling Environment Measurement

The schooling inputs include the teacher's experience and gender, student-teacher ratio, and the RIECE curriculum intervention (schooling intervention), primarily focusing on the Plan-Do-Review (PDR) process, a core activity of HighScope. See Epstein (2012) for more information on HighScope. The RIECE curriculum was not assigned at random in this program. All existing teachers in all participating centers were encouraged to implement the new curriculum into all of their classes. Then, the implementation of the curriculum was observed and recorded. Finally, the school intervention (adoption of curriculum) received by a school led to the assignment of value 1 if the school adopted the curriculum and zero otherwise. In April 2015, all teachers were invited to a two-day in-class training (98 percent participation rate) and a two-day intensive workshop (54 percent participation rate). By the end of the school year, only roughly 35% of classrooms (45 out of 127) had chosen to use the RIECE curriculum. Data on teachers and the adoption of the RIECE curriculum come from teacher interviews by the survey team of RIECE Thailand. The team began their visits in November 2015 and continued for four rounds until March 2016. According to the data, the adoption percentage among the adopted centers (23 out of 50) was over 65 percent. If childcare centers implement the RIECE curriculum, we create a dummy variable of School Intervention equal to 1 and 0 otherwise.

2.5 Other Covariates

Other relevant control variables include child gender and age, sibling dummy, and dummies for children having a history of chronic illnesses or low birth weight. Furthermore, there is ample evidence of the impact of wealth on a child's development (Miller et al., 2021), and wealth is also correlated with parental investment (Gibson & Sear, 2010). Therefore, we control for household wealth to mitigate its confounding effect on the relationship between parental investment and child development. The assessment of household wealth was derived from the responses provided by the head of the household in the household questionnaire. This comprehensive evaluation consists of 24 specific items, each inquiring about various asset holdings. These assets are systematically categorized into four distinct dimensions, reflecting different aspects of wealth and possession. The dimensions include housing, vehicles, gadgets, and electrical appliances. The EFA process was applied to measure wealth as described in the case of lagged child outcomes. See the online appendix for all items relating to household wealth and the corresponding EFA results.

Table 1. Descriptive statistics

	Mean	**Std. Dev.**	**Min**	**Max**
Tested child outcomes				
Aggregate	51.05	6.27	29.40	57.50
Gross motor	50.12	6.88	27.00	57.50
Fine motor	47.71	9.19	21.50	57.50
Receptive language	51.57	6.90	27.00	57.50
Expressive language	53.48	6.85	27.00	57.50
Personal-social	52.34	7.46	27.00	57.50
Lagged child outcomes				
Behavioral [a]	0.00	1.28	-5.74	1.82
Cognitive [a]	0.00	1.28	-5.89	1.72
Motor [a]	0.00	1.40	-4.81	1.98
Self-regulation [a]	0.00	1.32	-3.87	2.23
Lagged parental investments				
Material [a]	0.00	1.17	-1.62	11.53
Time [a]	0.00	1.28	-1.30	7.83
School inputs				
Teacher's experience	12.20	6.93	0.00	29.67
Male teacher	0.03	0.18	0.00	1.00
Student-teacher ratio	13.50	4.70	5.00	31.00
School intervention	0.40	0.49	0.00	1.00
Controls				
Lagged household wealth [a]	0.00	1.24	-2.69	5.50
Male child	0.51	0.50	0.00	1.00
Child age	48.79	6.94	29.00	61.00
Child age-squared	2428.12	661.55	841.00	3721.00
Child sibling	0.46	0.50	0.00	1.00

Child chronic	0.12	0.33	0.00	1.00
Low birth weight	0.08	0.28	0.00	1.00

Note: Number of observations is 630. a = latent variables.

3. Empirical Strategy

To investigate the relationship between tested child outcomes and lagged child outcomes, parental investments, and schooling inputs, we estimate the following linear model:

$$CT_{i,t} = \alpha_0 + \alpha_1 CO_{i,t-1} + \alpha_2 I_{i,t-1} + \alpha_3 S_{i,t} + \alpha_4 X_{i,t} + \varepsilon_t \quad (1)$$

where, $CT_{i,t}$ denotes tested child outcomes for child i at time t, which is a vector of gross and fine motor, receptive and expressive language, and personal-social outcomes, $CO_{i,t-1}$ is a vector of lagged observed child behavioral, cognitive, motor, and self-regulation skills, $I_{i,t-1}$ is a vector of parents' material and time investment, $S_{i,t}$ capture school inputs, including teachers' experience and gender, student-teacher ratio, and RIECE curriculum intervention (school intervention), $X_{i,t}$ denotes a vector of relevant control variables, and ε_t is the error term.

In the following, we estimate equation (1) using ordinary least square regression and consider the following specifications. Our main results consider the raw (not age-standardized) scores of our key variables and estimate the model with robust standard errors. Then, heterogeneity between the male and female children's sub-samples is investigated. Finally, to examine the robustness of the estimates, we consider (1) age-standardized scores for key explanatory variables, including lagged child outcomes and parental investments, (2) estimation with standard errors clustered at sub-district level, and (3) an alternative measurement of tested child outcomes (dependent variables) such that each sub-dimension is captured by a dummy that equals to one if the child passes the question in the test designed for their age, and zero if they fail the said question.

4. Results and Discussion

This section reports the estimated correlation between lagged child outcomes, parental investments, and schooling inputs with the tested child outcomes. For complete results, including the controls, see the online appendix.

Table 2 reports the estimates of equation (1) using ordinary least square regression. Relating to the cross-lagged nature of child outcomes, the estimation reveals that only child cognitive skills significantly determine future child outcomes in our sample (Table 2, Panel A). In particular, a child's cognitive outcome is significantly positively associated with the child's future gross motor and receptive and expressive language. The correlation between cognitive skills and language ability is consistent with previous findings by Dulay et al. (2021), who found a positive relationship between morphological awareness and later vocabulary knowledge. Similarly, we confirm earlier cognitive skills being associated with future motor development, which aligns with Wolf and McCoy (2019b). The insignificance of the remaining cross-lagged effects is inconsistent with the literature, i.e., motor ability leads to improved physical performance (Burns et al., 2022; Schmutz et al., 2020), and noncognitive skills lead to improved future cognitive and noncognitive skills (Liu et al., 2019; Slot et al., 2020). Our findings also fail to confirm within-skill correlations, such as executive function/motor leading to greater future executive functioning (Liu et al., 2019).

Relating to parental investment (Table 2, Panel B), we find that material investment is associated with improved expressive language, and time investment is positively significantly linked to each child's fine motor, expressive language, personal-social skills, and the aggregate measure of all skills. These findings are consistent with the literature on the positive link between parental time investment and the child's personal-social skills (2021) and cognitive skills (Cano et al., 2019; Del Bono et al., 2016). Our finding that time investment leads to improved fine motor skills is an addition to the existing literature. Previous studies have also significantly associated material investment with cognitive abilities (see Attanasio, Cattan, et al., 2020).

School inputs were also significantly linked to tested child outcomes (Table 2, Panel C). Teacher experience is positively linked with fine motor skills in children, and student-teacher ratio is positively linked to expressive language. Although we do not have a theoretical explanation, this finding is consistent with Bowne et al. (2017), who found that for a child-teacher ratio greater than 7.5:1 (and less than or equal to 15:1), an increase in the number of children will improve cognitive skills. Finally, the RIECE curriculum intervention is significantly linked to improved children's gross motor and receptive and expressive language skills. Our findings relating to the school intervention confirm the findings by Chujan and Kilenthong (2021) in the same context. However, we can account for more inputs in this case, thus providing more robust estimates.

Table 2. Main results

	Tested child outcomes					
	1: Aggregate	2: Gross motor	3. Fine motor	4. Receptive language	5. Expressive language	6. Personal-social
Panel A: Lagged child outcomes						
Behavioral	-0.035	-0.216	0.003	0.118	-0.274	0.195
	(0.133)	(0.222)	(0.269)	(0.200)	(0.197)	(0.209)
Cognitive	0.189	0.378*	-0.191	0.392**	0.375**	-0.006
	(0.125)	(0.215)	(0.268)	(0.186)	(0.184)	(0.188)
Motor	0.011	0.135	0.133	-0.083	-0.202	0.074
	(0.111)	(0.182)	(0.226)	(0.160)	(0.148)	(0.177)
Self-regulation	-0.078	-0.007	-0.113	-0.216	0.129	-0.181
	(0.121)	(0.194)	(0.247)	(0.179)	(0.173)	(0.193)
Panel B: Parental investments						
Material	0.099	0.155	0.202	0.170	0.277**	-0.308
	(0.137)	(0.244)	(0.300)	(0.163)	(0.140)	(0.200)
Time	0.236**	-0.050	0.453**	0.087	0.353***	0.336**
	(0.104)	(0.163)	(0.225)	(0.170)	(0.122)	(0.156)
Panel C: School inputs						
Teacher's experience	0.034*	0.000	0.065*	0.034	0.025	0.048
	(0.019)	(0.031)	(0.039)	(0.030)	(0.025)	(0.030)
Male teacher	0.093	-0.683	-0.322	0.965	0.432	0.072
	(0.786)	(1.185)	(1.469)	(0.952)	(0.903)	(1.199)
Student-teacher ratio	-0.004	0.012	-0.049	-0.037	0.066*	-0.011
	(0.026)	(0.048)	(0.057)	(0.038)	(0.038)	(0.042)
School intervention	0.538*	1.368***	-0.689	0.723*	0.878***	0.412
	(0.284)	(0.449)	(0.586)	(0.414)	(0.336)	(0.447)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	630	630	630	630	630	630

Note: Robust standard errors in parenthesis *, **, and *** denote 10%, 5%, and 1% significance.

4.1 Heterogeneity

Given the role of child's gender in the relationship between child development and parental investments (Moroni et al., 2021) and efforts (Faizi & Kilenthong, 2022), in this section, we investigate whether our results vary by child's gender. As such, Table 3 and Table 4 report estimations for female and male children's sub-samples.

A comparison of Panel A of Tables 3 and Table 4 reveals that gross motor in female children respond significantly negatively to lagged behavioral skills and positively to self-regulation skills. Moreover, consistent with our main results, lagged cognitive outcome improves gross motor and expressive language skills among female children. These estimates are insignificant for their male counterparts. On the other hand, the relationship between self-regulation and gross motor is positive for females but negative for males.

Relating to parental investments (Panel B of Table 3 and Table 4), we do not see significant opposing effects between the two sub-samples. However, while in female children, we observe that all dimensions of tested outcomes (except for gross motor) significantly positively respond to time investment, in their male counterparts, time investment only improves expressive language. An inverse pattern can be observed for material investment. Specifically, material investment is significantly related to fine motor outcomes in male children but insignificant across all dimensions of female children's outcomes.

The curriculum intervention (Panel C of Table 3 and Table 4) improves gross motor and expressive language abilities among female children but only improves gross motor outcomes among male children. This implies that more dimensions of female children's outcomes are sensitive to the RIECE curriculum intervention. The student-teacher ratio is positively correlated with expressive language in female children and negatively with fine motor responses in male children.

Table 3. Heterogeneity – female child

	Tested child outcomes					
	1: Aggregate	2: Gross motor	3. Fine motor	4. Receptive language	5. Expressive language	6. Personal-social
Panel A: Lagged child outcomes						
Behavioral	-0.158	-0.947***	0.095	0.092	-0.359	0.328
	(0.170)	(0.348)	(0.399)	(0.293)	(0.293)	(0.301)
Cognitive	0.130	0.608*	-0.642	0.274	0.578*	-0.169
	(0.168)	(0.320)	(0.420)	(0.277)	(0.297)	(0.269)
Motor	0.008	0.195	0.074	-0.172	-0.098	0.043
	(0.156)	(0.286)	(0.353)	(0.245)	(0.230)	(0.243)
Self-regulation	0.154	0.516*	0.225	-0.007	-0.022	0.058
	(0.158)	(0.286)	(0.344)	(0.295)	(0.230)	(0.282)
Panel B: Parental investments						
Material	-0.034	0.001	-0.178	0.108	0.245	-0.345
	(0.162)	(0.346)	(0.342)	(0.208)	(0.183)	(0.249)
Time	0.383***	-0.005	0.567*	0.448**	0.395**	0.511***
	(0.140)	(0.212)	(0.303)	(0.197)	(0.170)	(0.193)
Panel C: School inputs						
Teacher's experience	0.021	-0.000	0.034	0.033	0.011	0.030
	(0.025)	(0.042)	(0.055)	(0.038)	(0.033)	(0.039)
Male teacher	0.413	0.933	-1.841	1.634	0.672	0.668
	(0.885)	(1.570)	(1.921)	(1.010)	(1.081)	(1.371)
Student-teacher ratio	0.086**	0.089	0.133	0.047	0.113**	0.048
	(0.035)	(0.079)	(0.086)	(0.057)	(0.052)	(0.055)
School intervention	0.650	1.707**	-0.153	0.787	0.978*	-0.070
	(0.402)	(0.665)	(0.863)	(0.570)	(0.505)	(0.561)
Observations	306	306	306	306	306	306

Note: Robust standard errors in parenthesis *, **, and *** denote 10%, 5%, and 1% significance.

Table 4. Heterogeneity – male child

	Tested child outcomes					
	1: Aggregate	2: Gross motor	3. Fine motor	4. Receptive language	5. Expressive language	6. Personal-social
Panel A: Lagged child outcomes						
Behavioral	0.051	0.320	-0.147	0.184	-0.231	0.131
	(0.197)	(0.278)	(0.364)	(0.273)	(0.273)	(0.301)
Cognitive	0.181	0.187	0.055	0.427	0.141	0.095
	(0.185)	(0.289)	(0.369)	(0.266)	(0.239)	(0.281)
Motor	0.017	0.109	0.195	-0.057	-0.236	0.072
	(0.156)	(0.240)	(0.302)	(0.212)	(0.189)	(0.251)
Self-regulation	-0.270	-0.451*	-0.390	-0.393*	0.273	-0.392
	(0.179)	(0.262)	(0.342)	(0.222)	(0.244)	(0.272)
Panel B: Parental investments						
Material	0.288	0.359	0.716*	0.297	0.305	-0.236
	(0.187)	(0.277)	(0.391)	(0.239)	(0.195)	(0.320)
Time	0.047	-0.169	0.368	-0.355	0.304*	0.089
	(0.154)	(0.264)	(0.368)	(0.244)	(0.178)	(0.276)
Panel C: School inputs						
Teacher's experience	0.041	0.005	0.079	0.027	0.037	0.054
	(0.029)	(0.044)	(0.055)	(0.045)	(0.036)	(0.045)
Male teacher	-0.128	-2.189	1.549	0.347	0.337	-0.685
	(1.432)	(1.710)	(2.204)	(1.817)	(1.530)	(2.163)
Student-teacher ratio	-0.060	-0.010	-0.171**	-0.083	0.015	-0.051
	(0.037)	(0.058)	(0.078)	(0.052)	(0.053)	(0.063)
School intervention	0.499	1.271**	-1.119	0.643	0.748	0.951
	(0.394)	(0.616)	(0.810)	(0.590)	(0.460)	(0.692)
Observations	324	324	324	324	324	324

Note: Robust standard errors in parenthesis *, **, and *** denote 10%, 5%, and 1% significance.

4.2 Robustness

In this section, we perform robustness across three alternative empirical specifications. First, following Attanasio et al. (2020), we considered age-standardized scores of our key explanatory variables, including lagged child outcomes and parental investments, to remove the effect of age. Second, we consider our model with clustered standard errors at the sub-district level to account for heterogeneities across sub-districts that could affect the child's environment. Finally, we consider an alternative grading of tested child outcomes. Our original measure involved the number of questions each child passed or answered correctly. For robustness, we consider a dummy variable, which equals one if the child passes the question designed for the child's age and zero if the child fails this question (see Table 5 for summary statistics). This method restricts each child's score to the pass or fail rate in their age-appropriate questions.

Table 5. Descriptive statistics of dummy dependent variables

	Mean	**Std. Dev.**	**Min**	**Max**
Tested child outcomes				
Aggregate [a]	0.69	0.46	0.00	1.00
Gross motor [a]	0.62	0.49	0.00	1.00
Fine motor [a]	0.39	0.49	0.00	1.00
Receptive language [a]	0.71	0.46	0.00	1.00
Expressive language [a]	0.81	0.40	0.00	1.00
Personal-social [a]	0.72	0.45	0.00	1.00

Note: Number of observations is 630. a = age-standardized.

4.2.1 Robust Results

The positive relationship between lagged child's cognitive and current gross motor, receptive language, and expressive language outcomes is confirmed in the estimation with age-standardized explanatory variables (Table 6, Panel A). However, our estimation with clustered standard errors at the sub-district level only confirms the significant coefficients of lagged cognitive outcome with receptive and expressive language (Table 7, Panel A), and our estimates with dummy as our dependent variable confirms that lagged cognitive outcome is significantly positively linked to gross motor (Table 8, Panel A). Some less consistent findings include lagged behavioral outcomes being significantly negatively linked to expressive language (Table 7, Panel A) and significantly positively linked to receptive language (Table 8, Panel A) and lagged motor and self-regulation being significantly negatively linked to expressive and receptive language skills, respectively (Table 8, Panel A). These estimates were insignificant in our main results.

Our estimation confirms all the correlations corresponding to parental investment with clustered standard errors (Table 7, Panel B). Furthermore, both the age-standardized model and the model with the dummy outcome variables confirm that time and material investments are positively linked to child's future expressive language (Table 6 and Table 8, Panel B). A new finding comes from the age-standardized model where material investment is significantly negatively linked to future personal-social skills (Table 6, Panel B), while this result was negative but insignificant in our main result.

Similarly, our estimation with age-standardized explanatory variables confirms all the correlations corresponding to schooling inputs (Table 6, Panel C). However, the clustered-standard errors at the sub-district level only confirm the positive correlation between RIECE curriculum intervention and child's gross motor and expressive language (Table 7, Panel C). This is also confirmed by using a pass/fail dummy as our dependent variable (Table 8, Panel C). In addition, Table 8, Panel C, confirms that the student-teacher ratio is positively associated with expressive language, while, in addition, it shows that this ratio is negatively linked to child's receptive language. However, this correlation is found to be small in magnitude and less significant.

Table 6. Robust: Age-standardized explanatory variables

	Tested child outcomes					
	1: Aggregate	2: Gross motor	3. Fine motor	4. Receptive language	5. Expressive language	6. Personal-social
Panel A: Lagged child outcomes						
Behavioral [a]	0.022	-0.292	0.099	0.180	-0.235	0.361
	(0.162)	(0.272)	(0.329)	(0.242)	(0.234)	(0.251)
Cognitive [a]	0.283*	0.522**	-0.124	0.569***	0.454**	-0.007
	(0.153)	(0.266)	(0.325)	(0.216)	(0.219)	(0.229)
Motor [a]	-0.049	0.174	-0.013	-0.136	-0.277	0.008
	(0.141)	(0.239)	(0.291)	(0.204)	(0.180)	(0.220)
Self-regulation [a]	-0.111	-0.032	-0.044	-0.327	0.078	-0.232
	(0.155)	(0.254)	(0.317)	(0.224)	(0.214)	(0.248)
Panel B: Parental investments						
Material investment [a]	0.056	0.142	0.107	0.153	0.296*	-0.420*
	(0.155)	(0.261)	(0.329)	(0.202)	(0.166)	(0.240)
Time investment [a]	0.213	-0.095	0.414	0.064	0.369**	0.312
	(0.130)	(0.210)	(0.280)	(0.204)	(0.151)	(0.207)
Panel C: School inputs						
Teacher's experience	0.035*	0.001	0.068*	0.033	0.026	0.049
	(0.019)	(0.031)	(0.039)	(0.030)	(0.025)	(0.030)
Male teacher	-0.090	-0.787	-0.326	0.806	0.156	-0.302
	(0.805)	(1.222)	(1.518)	(0.970)	(0.893)	(1.207)
Student-teacher ratio	-0.005	0.011	-0.050	-0.038	0.064*	-0.009
	(0.026)	(0.047)	(0.056)	(0.038)	(0.038)	(0.042)
School intervention	0.535*	1.366***	-0.712	0.721*	0.874***	0.425
	(0.284)	(0.449)	(0.587)	(0.414)	(0.336)	(0.448)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	629	629	629	629	629	629

Note: Robust standard errors in parenthesis *, **, and *** denote 10%, 5%, and 1% significance. a = denotes age-standardized variables.

Table 7. Robust: Clustered standard errors at sub-district level

	Tested child outcomes					
	1: Aggregate	2: Gross motor	3. Fine motor	4. Receptive language	5. Expressive language	6. Personal-social
Panel A: Lagged child outcomes						
Behavioral	-0.035	-0.216	0.003	0.118	-0.274*	0.195
	(0.112)	(0.201)	(0.271)	(0.177)	(0.154)	(0.182)
Cognitive	0.189	0.378	-0.191	0.392**	0.375*	-0.006
	(0.129)	(0.247)	(0.198)	(0.149)	(0.182)	(0.183)
Motor	0.011	0.135	0.133	-0.083	-0.202	0.074
	(0.105)	(0.260)	(0.188)	(0.160)	(0.175)	(0.151)
Self-regulation	-0.078	-0.007	-0.113	-0.216	0.129	-0.181
	(0.124)	(0.251)	(0.343)	(0.169)	(0.145)	(0.173)
Panel B: Parental investments						
Material	0.099	0.155	0.202	0.170	0.277*	-0.308
	(0.147)	(0.251)	(0.331)	(0.207)	(0.145)	(0.187)
Time	0.236**	-0.050	0.453**	0.087	0.353***	0.336**
	(0.090)	(0.174)	(0.186)	(0.144)	(0.101)	(0.125)
Panel C: School inputs						
Teacher's experience	0.034	0.000	0.065	0.034	0.025	0.048
	(0.026)	(0.034)	(0.043)	(0.035)	(0.026)	(0.043)
Male teacher	0.093	-0.683	-0.322	0.965	0.432	0.072
	(0.788)	(1.167)	(1.124)	(0.669)	(0.730)	(1.269)
Student-teacher ratio	-0.004	0.012	-0.049	-0.037	0.066	-0.011
	(0.032)	(0.038)	(0.045)	(0.044)	(0.067)	(0.056)
School intervention	0.538	1.368***	-0.689	0.723	0.878**	0.412
	(0.380)	(0.451)	(0.594)	(0.500)	(0.377)	(0.557)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	630	630	630	630	630	630

Note: Robust standard errors, clustered at sub-district level, in parenthesis *, **, and *** denote 10%, 5%, and 1% significance.

Table 8. Robust: pass/fail dummy as dependent

	Tested child outcomes					
	1: Aggregate	2: Gross motor	3. Fine motor	4. Receptive language	5. Expressive language	6. Personal-social
Panel A: Lagged child outcomes						
Behavioral	0.023	-0.015	0.018	0.031*	-0.006	0.028
	(0.016)	(0.019)	(0.020)	(0.017)	(0.016)	(0.018)
Cognitive	0.015	0.033*	-0.023	0.023	0.012	0.001
	(0.015)	(0.018)	(0.020)	(0.016)	(0.015)	(0.016)
Motor	-0.011	0.011	-0.006	-0.003	-0.027**	-0.008
	(0.013)	(0.015)	(0.017)	(0.013)	(0.012)	(0.015)
Self-regulation	-0.021	-0.010	-0.019	-0.025*	0.011	-0.019
	(0.015)	(0.016)	(0.018)	(0.015)	(0.014)	(0.016)
Panel B: Parental investments						
Material	0.003	0.001	0.022	0.018	0.029**	-0.012
	(0.017)	(0.018)	(0.020)	(0.014)	(0.011)	(0.017)
Time	0.013	-0.006	0.027	-0.005	0.017*	0.016
	(0.012)	(0.016)	(0.016)	(0.015)	(0.010)	(0.012)
Panel C: School inputs						
Teacher's experience	0.005**	-0.000	0.003	0.001	-0.002	0.001
	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Male teacher	0.021	-0.012	0.023	0.058	0.078	0.075
	(0.097)	(0.103)	(0.115)	(0.086)	(0.087)	(0.101)
Student-teacher ratio	-0.003	0.003	-0.005	-0.007*	0.006*	0.001
	(0.004)	(0.004)	(0.005)	(0.004)	(0.003)	(0.004)
School intervention	0.037	0.126***	-0.059	-0.000	0.062**	0.044
	(0.034)	(0.039)	(0.044)	(0.035)	(0.029)	(0.037)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	630	630	630	630	630	630

Note: Robust standard errors in parenthesis *, **, and *** denote 10%, 5%, and 1% significance.

Conclusion

The present study investigates the effect of lagged child skills, parental investments, and school environment on early childhood development in the context of rural Thailand. The empirical analysis on a sample of 630 children reveals that lagged child cognitive ability has a positive relationship with gross motor and language skills in the present. In the aspect of parental investments, time investment improves fine motor, receptive language, and personal-social abilities, while material investment was only correlated with expressive language. Relating to the schooling environment, the RIECE curriculum intervention positively contributes to gross motor and expressive and receptive language skills. On the other hand, teachers' experience and higher student-teacher ratio improve fine motor and expressive language skills, respectively. These findings varied by child gender.

Our findings have some key implications. First, we confirm that lagged child outcomes positively correlate with future outcomes. As such, early child development is of great significance due to the accumulating nature of human capital. Therefore, sufficient attention needs to be directed to early childhood development. Second, we find that in our context, time investment is significant across more dimensions of child outcomes than material investment. This can inform parents' time and material allocation decisions. Third, the school environment, including the teacher's experience and student-teacher ratio, shapes early childhood skills. Thus, improving the quality of these inputs should be a policy consideration for human capital development in rural areas. Finally, we also show that the positive impact of the Perry Preschool Project can be replicated in the context of rural Thailand.

This study is not without limitations. Due to data limitations, we are not able to address the endogeneity issue in our estimation that may arise from (1) unobserved individual effects and (2) omitted variables that affect both child outcomes and parental investments, such as parents' personalities. Nevertheless, the silver lining is that the RIECE data is still expanding across time and the scope of the questionnaire. Therefore, we hope that with the availability of panel data in the future, we can address the endogeneity issue, particularly relating to unobserved individual effects. At the same time, given that future surveys include more variables, such as relating to the caregivers' personalities, we will be able to mitigate confounding effects from omitted variables.

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