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April 12, 2024

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1 Introduction

What are the resources used for the welfare of young children in contemporary societies? What is the return to society of early childhood education? By addressing these questions, Psacharopoulos (1982) highlighted the importance of comprehending the economic underpinnings of early childhood education and daycare. Over four decades later, these questions remain as pertinent as ever, with a growing body of research emphasizing the critical role of early childhood interventions like preschooling and Head Start programs in shaping long-term educational and labor market outcomes (e.g., Cunha et al. (2006); Gertler et al. (2014)). Numerous studies have assessed the impact of early intervention initiatives such as the Perry Preschool Project and the Head Start Program on both short-term and long-term outcomes for children from disadvantaged backgrounds (e.g., Garces et al. (2002); Barnett (2004); Belfield et al. (2006); Heckman et al. (2010a,b)). Collectively, these studies consistently reveal positive effects, including higher wages, increased educational attainment, and reduced likelihood of criminal involvement later in life.[1]

The primary challenge in this body of research lies in accurately estimating the rate of return to early childhood interventions while accounting for long-term child outcomes. One of the seminal studies in this area is that of Heckman et al. (2010b), who estimated the rate of return on the Perry Preschool Program, factoring in social and economic outcomes up to age 40. Their analysis considered various potential biases and assumptions, including compromised randomization, deadweight loss (DWL) associated with tax financing, and imputation and extrapolation of missing earnings. Their findings indicated a rate of return between 7% and 10%. However, given the limited scale of the Perry intervention, it remains uncertain whether a universal intervention policy, such as a statewide expansion of preschool programs, would yield similar effects, especially considering potential general

[1] Garces et al. (2002) find that children participating in the Head Start program tend to exhibit higher wages, an increased likelihood of high school graduation, an elevated probability of college enrollment, and a reduced propensity for engaging in criminal activities during their early twenties. Barnett (2004) delves into the long-term effects of the Perry Preschool Project, examining outcomes at age 27, while Belfield et al. (2006) provides further updates on these effects at age 40. Meanwhile, Heckman et al. (2010a) and Akabayashi and Tanaka (2013) have conducted an in-depth examination of both short-term and long-term program effects, employing rigorous statistical analysis. For comprehensive overviews of early interventions' effects, refer to Currie (2001) and Blau and Currie (2006).

equilibrium impacts.

This study, building upon our previous research (Akabayashi and Tanaka (2013)), provides a fresh estimate of the rate of return to early childhood education programs. In Japan, children under six years of age can optionally attend kindergarten or nursery schools for two or more years before elementary school. Leveraging prefecture-level panel data, we initially estimate the impact of preschool enrollment on high school graduation and college advancement rates among men. These estimates, in conjunction with national fiscal records, enable us to calculate the rate of return on early childhood education. This paper represents one of the first attempts to estimate the rate of return using Japanese data. [2]

To identify causal effects of preschool enrollment, we leverage a national policy implemented in 1964 that triggered an expansion in kindergarten enrollment rates. In 1963, the central government unveiled a seven-year plan, known as the First Plan for Promoting Kindergarten Education, to increase the enrollment rate of two- or three-year kindergartens from 39% to 63.5%.[3] Because the enrollment rate in 1964 varied widely across cities and prefectures, this new policy undoubtedly affected local educational authorities in different magnitudes. The differential enrollment rates in 1964 across cities and prefectures, combined with Japan's unique dual preschool system where full-time nursery schools also accommodate kindergarten-age children with working mothers, provide a quasi-experimental setting for our analysis of later expansion of preschool enrollment.

We estimate the effects of preschool enrollment expansion on high school graduation and college advancement rates, using the rapid expansion of preschool enrollment driven by exogenous policy changes. However, measures of preschool education at the prefecture-level may still be endogenous due to factors like differential availability. To address this potential issue, we estimate the model by both simple ordinary least squares (OLS) and an instrumental variable (IV) method with the number of Buddhist and Christian institutions per capita and the gap between the policy target (i.e., 63.5%) and the kindergarten enrollment rate at age 2 serving as instruments as in Akabayashi and Tanaka (2013). Estimates with the instrument reveal that

[2]In this paper, we focus only on men because it is difficult to estimate the long-term monetary benefits of preschool education for women whose labor market attachment was much lower than men during the period we studied.

[3]This policy was followed by the Second Plan in 1971.

a one percentage point increase in kindergarten attendance rate generates roughly a 0.3 percentage point increase in high school graduation rates and a 0.1 percentage point increase in college enrollment rates. A one percentage point increase in nursery school attendance rate generates a roughly 0.9 percentage point increase in high school graduation rates and a 0.3 percentage point increase in college enrollment rates.

For the calculation of the internal rate of return, we firstly construct the per child fiscal cost of kindergarten and nursery school attendance using government fiscal records from the 1950s to 1970s. We also use national average age-earnings and employment rate data to estimate the pecuniary benefit of preschool enrollment, factoring in the deadweight loss due to income tax financing (Heckman et al. (2010b), and Bessho and Hayashi (2013)). Then, we calculate the internal rates of return for kindergarten and nursery school attendance separately. Our results indicate that, even with an extensive sensitivity analysis, the rate of return for preschool attendance falls between 5.7% and 8.1%.

This paper is related to the strand of literature on the effect of early childhood intervention on adult outcomes. Extensive research has been conducted on the short-term effects of early intervention on children from disadvantaged households (e.g., Currie and Thomas (1995); Currie (2001)) and its long-term effects by Garces et al. (2002) and Ludwig and Miller (2007). Among them, Garcia et al. (2020) has quantitatively assessed and aggregated the multifaceted lifetime benefits of a high-quality early childhood program with outcomes measured through midlife, concluding that the internal rate of return stands at 13.7%, accompanied by a consequential benefit-to-cost ratio of 7.3. It is worth noting that these investigations have primarily focused on the effects of early intervention on children from disadvantaged backgrounds. In contrast, the present study distinguishes itself by examining the impact of a universal intervention on the entire population.

Several studies investigate the effects of universal early intervention on the education of children in the entire population (Gormley and Gayer (2005); Baker et al. (2008); Berlinski et al. (2009)), focusing on short-term outcomes rather than long-term effects. However, inferring long-term policy implications solely from short-term outcomes is a complex endeavor, given that numerous previous studies have illustrated the transitory nature of the cognitive benefits associated with preschool attendance (Duncan

and Magnuson (2013)). Furthermore, research indicates that non-cognitive development may hold more significance in early childhood development, particularly in the age range of 3 to 5 (Heckman et al. (2010a,b)).

There are several papers estimating the impact of preschool attendance on a multitude of outcomes and the rate of return linked to universal preschool education. Arteaga et al. (2014) explores the effects of preschool duration on adult outcomes, such as special education enrollment and criminal behavior. Cascio and Schanzenbach (2013) escrutinize the effects of the introduction of universal preschool programs in Georgia and Oklahoma since the 1990s, identifying a positive impact on children's test performance lasting until the eighth grade, predominantly among lower-income families. Notably, van Huizen et al. (2019) shares a methodological affinity with our study, as they endeavor to synthesize diverse data sources to ascertain benefits and costs, leveraging a policy reform in Spain as a source of causal inference. It is pertinent to note that while our dataset does not consist of individual-level data, it provides a more comprehensive and systematic perspective, encompassing wage data spanning the entire work history of the population influenced by the policy.

The present research contributes to the expanding body of literature that assesses the impact of early childhood education on diverse outcomes, particularly in the context of Japan and other Asian nations. Kawarazaki (2022) delves into the examination of a universal early childhood education program, offering a comprehensive analysis of its long-term effects and the underlying mechanisms at play. This study illuminates a positive correlation between the program and income levels, persisting until age 50. In parallel, Ando et al. (2022) investigate the implications of early childhood education on risky behaviors during adolescence. Their findings highlight the substantial benefits of early childhood education expansion, particularly in terms of diminished rates of juvenile violent arrests and reduced teenage pregnancy rates. Furthermore, Akabayashi et al. (2023) contribute by estimating the causal effects of education-oriented versus care-oriented preschools on child development. Leveraging data collected from school-age children in the 2010s, this study finds significant enhancements in mathematical and linguistic achievement among children who attended education-oriented preschools, with these improvements manifesting into early adolescence. Notably, they reveal that the children who are least likely to enroll in education-oriented

preschools stand to gain the most from such programs. In the Chinese context, Yang (2021) investigates the long-term consequences of early childhood education and care attendance in China, focusing on adults over the age of 18. This study establishes a positive relationship between early childhood education and care experiences and enhanced cognitive and non-cognitive skills in adulthood. Collectively, these studies underscore the importance of early childhood education in influencing a spectrum of outcome variables. Our research serves to augment the body of evidence emphasizing the critical role of early childhood education, examining the causal effects of early childhood education on later educational achievement, and providing estimates of internal rates of return by analyzing the universal expansion of preschools in Japan during the years 1960-1980.

The remainder of this paper is structured as follows: Section 2 provides a brief overview of Japan's preschool education system. Section 3 describes the econometric model and the identification strategy. Section 4 details the data used, and Section 5 reports the estimates of the effects of preschooling on educational attainment. Section 6 presents the empirical results of the rate of return to preschool education, and finally, Section 7 offers concluding remarks.

2 Early childhood education in Japan

This section provides a concise overview of the institutional background of the Japanese early childhood education system and details the 1964 national policy implementation aimed at boosting kindergarten enrollment rates.

2.1 Preschools in Japan

All Japanese children aged six years, as of April 1st, are required to commence their education in elementary schools. These elementary schools follow a six-year curriculum, after which children must continue their education in junior high school for three years. Prior to commencing the nine-year compulsory education, however, many children attend preschools.

In Japan, the two primary options for preschool education are two- or three-year part-time kindergartens and full-time nursery schools, each historically designed with distinct purposes and characteristics. On one hand, kindergartens were originally established to facilitate the holistic develop-

ment of preschool children, nurturing their cognitive and physical abilities by providing a conducive educational environment for 3- to 5-year-olds, typically offering one- to three-year courses. Presently, the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) prescribes and oversees the curriculum of kindergartens, with kindergarten teachers being required to obtain certification from the Ministry.

On the other hand, nursery schools initially served as childcare providers for children whose parents (or legal guardians) were unable to provide care due to work commitments or other reasons. The Ministry of Health, Labour, and Welfare defines the guidelines for nursery schools, and those responsible for childcare must obtain certification as "childcare personnel." Nursery schools, in addition to childcare, also provide educational services for children aged five and below.

Notwithstanding their divergent origins and administrative frameworks, these two types of institutions share numerous overlapping roles, especially with regard to providing education to preschool-aged children. Consequently, many individuals consider these two types of schools to be roughly equivalent.[4]

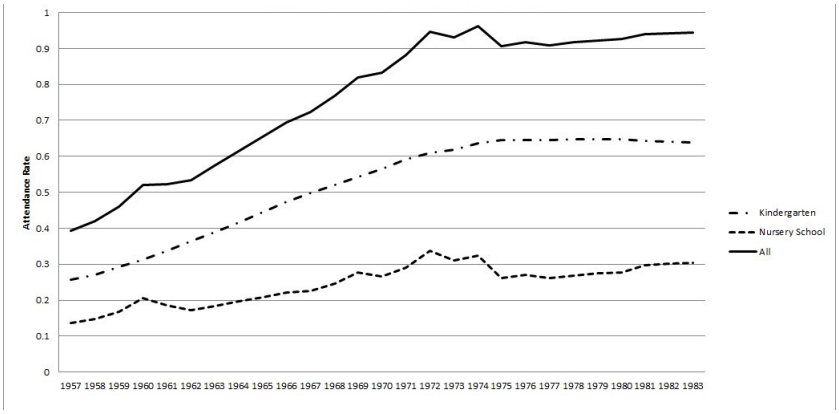
Japan encompasses both local public and private kindergartens and nursery schools. Several private kindergartens and nursery schools were initially established and operated by religious organizations, including Buddhism and Christianity. According to data from The Ministry of Education (1979), private kindergartens constituted 64% of preschools in 1969, with 27% of them having been established by religious organizations.

2.2 Post-war expansion of early childhood education

Japan has undergone a substantial and rapid expansion in preschool enrollment since the early 1950s. The overall preschool attendance rate, encompassing both kindergartens and nursery schools, has consistently exceeded 90% since 1970, a remarkable increase from the approximately 40% rate recorded in 1954. As depicted in Figure 1, the average kindergarten enrollment rate surged from 21.8% in 1954 to 64% in 1975.

[4]In fact, the Japanese government is currently in the process of amalgamating two preschool education institutions into a single entity. The MEXT is actively promoting the adoption of a system established in Fiscal Year 2006 known as the "Center for Early Childhood Education and Care." This system offers integrated education and childcare services, along with an Action Program for the Promotion of Pre-School Education.

Figure 1: Preschool enrollment trend: 1953-1988



Significant regional disparities in preschool enrollment rates were evident in the 1950s, as illustrated in Figure 2. Notably, the lowest and highest overall enrollment rates in 1954 were 8.8% in Aomori Prefecture and 80.1% in Kagawa Prefecture, respectively. For instance, in 1954, Ibaraki and Tottori Prefectures exhibited nearly identical kindergarten enrollment rates of 7%. However, by 1975, Ibaraki's enrollment rate had reached 64%, whereas Tottori's rate had remained at 35% (see Figure 3).

Throughout the 1960s and 1970s, both kindergarten and full-time nursery school enrollment rates experienced rapid growth. This surge in kindergarten enrollment was partially attributed to a universal policy intervention by the Japanese government, initiated in the 1960s. In 1964, the central government introduced the First Plan for Promoting Kindergarten Education, a seven-year initiative aimed at increasing the enrollment rate of two- or three-year kindergartens in cities with populations exceeding 10,000. The goal was to elevate this rate from 39% to 63.5% by establishing at least one kindergarten in every such city. To support this endeavor, the Japanese government significantly augmented the budget allocation for preschools, with a special focus on kindergartens. Figure 4 provides a graphical representation of the logarithmic ratios of kindergarten and nursery school subsidies to the national GDP between 1955 and 1990. This data clearly reveals the expansion of both subsidies, particularly for kindergartens, during the 1960s and 1970s.

We seek firstly to assess the impact of preschool attendance on children's educational achievements. To achieve this, we leverage the substan-

Figure 2: Kindergarten and nursery school enrollment in 1954

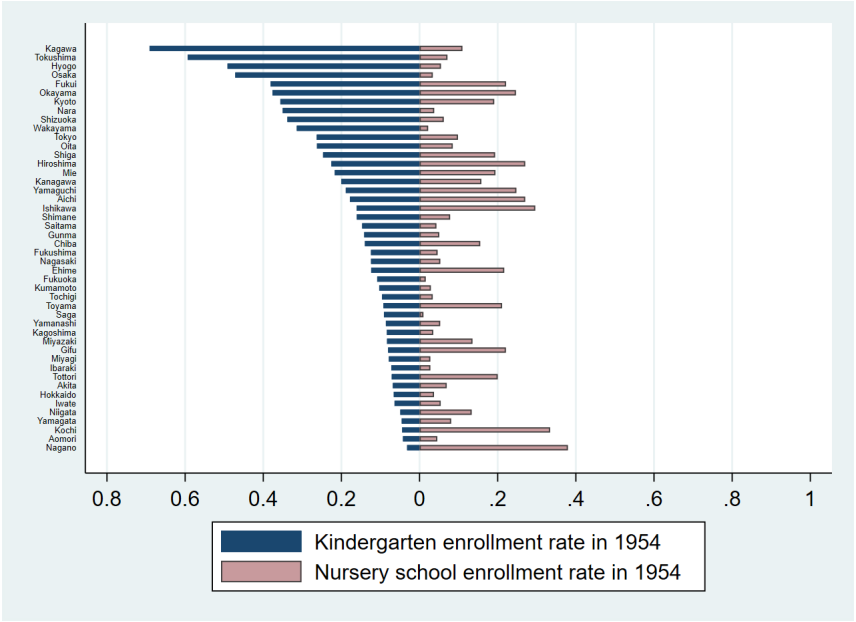


Figure 3: Kindergarten and nursery school enrollment in 1975

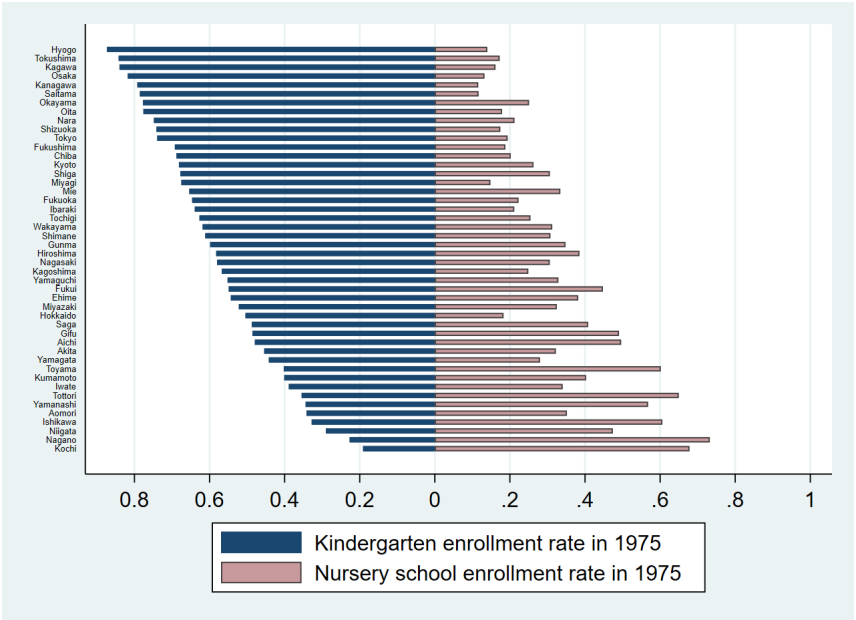
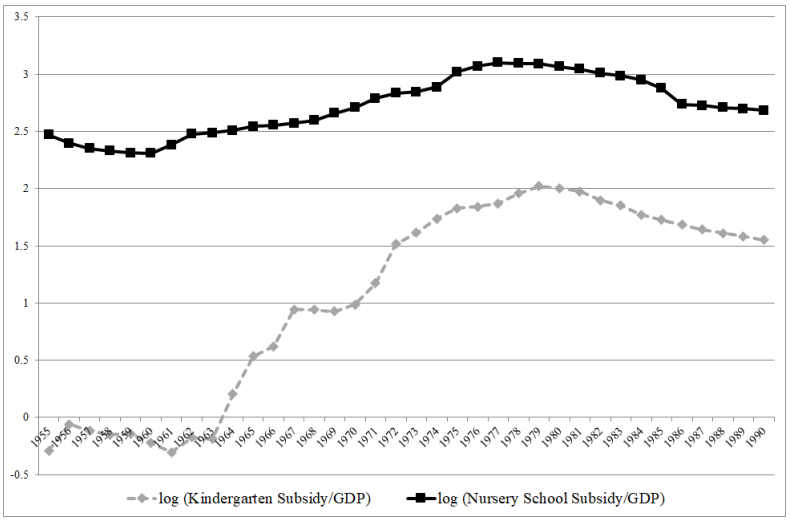


Figure 4: Fiscal expansion: 1955-1990



tial cross-prefectural variation in preschool enrollment growth, potentially stemming from national government initiatives supported by increased financial resources. Figures 5 and 6 depict the growth in kindergarten and nursery school enrollment rates from 1954 to 1975 for each prefecture, respectively. Notably, the significant variation in kindergarten enrollment rate growth resulting from the 1964 government intervention is evident across prefectures, creating varying pressures on local educational authorities (as depicted in Figure 5). Japan's dual preschool system, accommodating both kindergarten-age children and those with working mothers, further adds to the policy divergence across prefectures (as indicated in Figure 6).

Leveraging these unique institutional dynamics within the early childhood education system in Japan, we aim to identify the impact of preschool attendance on children's educational outcomes and, consequently, calculate their rates of return.

3 The econometric model

This section provides a detailed exploration of the econometric model and the identification strategy employed in our analysis. To evaluate the impact of preschool attendance on high school graduation and college advancement

Figure 5: Kindergarten enrollment from 1954 to 1975

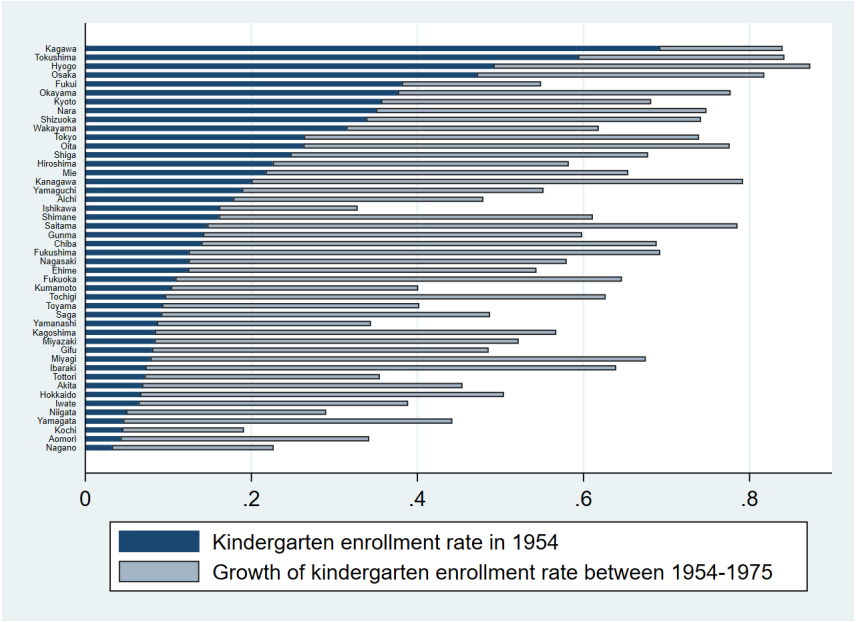
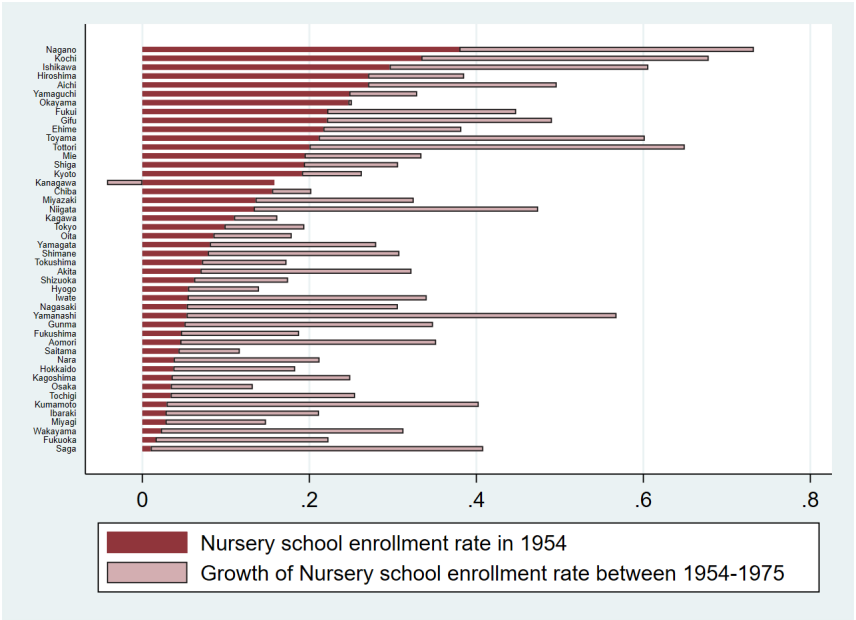


Figure 6: Nursery school enrollment from 1954 to 1975



rates, we estimate the following model:

$$y_{it} = \beta_0 + \beta_1 kind_{it-12} + \beta_2 nurse_{it-12} + X_{it}\gamma + c_i + d_t + \varepsilon_{it}, \qquad (1)$$

where y_{it} is either the high school graduation rate in year t or the college advancement rate in year t for prefecture i; $kind_{it-12}$ and $nurse_{it-12}$ are enrollment rates in kindergartens and nursery schools in year $t-12$ for prefecture i as the preschool attendance rates at age five were measured 12 years prior to the outcome measures; X_{it} are controls such as female ratio; c_i and d_t are prefecture and year dummies, respectively; and ε_{it} is an error term.

The estimation of this equation via the two-way fixed effect model serves as the basis for our results. We employ prefecture fixed effects in the regression equation to account for time-invariant, prefecture-specific unobserved heterogeneity. This serves to partially, if not entirely, mitigate the potential endogeneity resulting from such unobserved heterogeneity.

Since we utilize prefectural statistics, rather than individual-level data, to estimate the impact of kindergarten and nursery enrollment rates on school outcomes 12 years later, aligning data from various sources by year and prefecture necessitates several assumptions for the validity of our approach. First, there is no delayed or early enrollment in schools. Second, there is no grade repetition. Third, the enrollment levels in kindergarten and nursery at age 5 reflect the enrollment levels of younger children in each prefecture. Fourth, inter-prefectural migration during the study period is negligible. In Appendix C, we discuss in detail how our approach remains reasonably valid, considering the institutional settings of Japan and additional evidence.

To further strengthen our findings and assess the robustness of the results, we provide estimates through instrumental variable methods. Initially, we utilize the generalized method of moments (GMM), followed by the application of GMM with HAC (heterogeneity and autocorrelation consistent). This analysis aims to ascertain whether our results withstand the potential presence of endogeneity in the past enrollment rates of kindergartens and nursery schools.

As for the supply factor, we choose the number of Buddhist and Christian institutions within the population as instruments for the enrollment

rates in kindergartens and nursery schools. As previously discussed in 1 and 2.1, these variables possess a historical determination and can serve as instruments for the enrollment rates in preschools. This is due to the fact that many religious groups in Japan, including Buddhism and Christianity, have established private kindergartens and nursery schools. In addition to the religious institutions, we use the gap between the policy target (i.e., 63.5%) and the total kindergarten enrollment ratio at t-3 as an instrument for the male kindergarten enrollment rate in year t. The rationale for using the gap at t-3 as an instrument is to provide a political incentive to increase kindergarten enrollment up to the policy goal. If enrollment in age 5 classes increases only after the approval, construction, and recruitment process to establish new kindergartens, it takes at least three years. Specifically, what tends to happen in terms of policy is a case where capacity is increased from the lowest 3-year-old classes rather than a sudden increase in children entering kindergarten at age 5. In that case, it would take two years for the capacity expansion to reach the 5-year-old class we use for the measurement of the enrollment rate because the capacity improvement proposal/decision and room expansion would be completed at least one year before the 3-year-old capacity increase, there would still be a 3-year lag. The gap is set to 0 if the kindergarten enrollment ratio is above 63.5 percent.

4 Data

4.1 Preschool attendance and educational achievement

In conducting our estimation, our data set is meticulously constructed from a variety of information sources. The principal source for enrollment rates is the School Basic Survey, spanning from 1951 to 1999, as provided by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). For nursery school enrollment rates, we draw upon reports published by the Ministry of Health, Labor, and Welfare (MHLW).

The School Basic Survey represents an annual census survey administered by the MEXT, designed to compile fundamental information concerning educational institutions of all levels. This includes data on the number of students and teachers, students' post-graduation courses, and the current financial resources and assets of schools. At the prefecture-level, panel data are publicly accessible across several volumes of these surveys.

To elucidate our approach, we will now outline the construction of variables utilized in our analysis. We identify two variables as indicators of educational outcomes: the High School Graduation Rate and the 4-Year College Advancement Rate. The High School Graduation Rate is defined as the gross high school graduation rate, which reflects the ratio of high school graduates to the number of students in the 9th grade, the final year of compulsory schooling, occurring three years prior. The 4-Year College Advancement Rate is derived from data on how many high school graduates in a given prefecture transitioned to a 4-year college. This rate is calculated as the ratio of college students among high school graduates to the number of students in the 9th grade, also measured three years prior.

For the kindergarten enrollment rate at age five, we ascertain it through the ratio of the number of five-year-old pupils attending kindergartens in the preceding year to the number of students in the first grade of elementary schools. Since elementary school attendance is compulsory, the number of first-grade students theoretically represents the maximum number of five-year-olds enrolled in kindergartens in the preceding year.

Regarding the nursery school enrollment rate at age five, data is sourced from the 1953-1977 Case Reports of the Welfare Administration (CRWA: Fukushi Gyosei Houkoku Rei) and the 1977-1992 Survey of Social Welfare Facilities (SSWF: Shakai Fukushi Shisetsu Chosa Houkoku), both provided by the MHLW.[5] The two data sets have complementary strengths and weaknesses. These two datasets possess complementary strengths and weaknesses. The CRWA records nursery school enrollment on March 1st, segmented into four "administrative age" categories (defined as age on April 1), while the SSWF records nursery school enrollment on October 1st, based on the real (biological) age as of October 1st. Although the SSWF offers a detailed breakdown of enrollment by age category, it measures ages as of October 1st rather than April 1st. Nearly half of the five-year-old enrollment in the SSWF should be attributed to "administrative age 4" based on the CRWA records.

To approximate the nursery school enrollment rate relative to the April 1st elementary school enrollment for years preceding 1977, which are omitted

[5]The nursery school data are unavailable for the years 1963-1965. To address this gap in our analysis, we applied linear interpolation to estimate the missing data. In a robustness check, we repeated the same estimations using data from 1964 onward, and found that these results closely mirrored our initial findings.

in the CRWA data, we construct a proxy measure of "administrative age" 5 enrollment by utilizing the SSWF "real age" total enrollment for the age category of 4 and 5. While no method is perfect given the limited data, we simply apply weights for each age group derived from the average "real age" distribution in the SSWF. In periods of increasing enrollment, our estimates of five-year-olds' enrollment prior to 1977 may exhibit an upward bias. However, we assume that this type of measurement error becomes negligible after accounting for year-specific effects.

Incorporating control variables, we include real gross domestic expenditure (GDE) per capita and the male-to-female ratio. Real GDE data is obtained from relevant volumes of the Cabinet Office's Annual Report on Prefectural Accounts, and it is divided by the prefectural population, sourced from the MHLW's Vital Statistics of Japan. The male-to-female ratio is calculated as the proportion of girls in the first grade of elementary schools, as reported in the School Basic Survey.

Our econometric analysis takes into consideration the potential endogeneity of kindergarten and nursery school enrollment rates. As in instrument, we employ the number of Buddhist and Christian institutions in addition to the gap between the policy target (i.e., 63.5%) and 3-year lagged kindergarten enrollment rate. Information on the number of Buddhist and Christian institutions by prefecture is extracted from the relevant volumes of the Agency of Cultural Affairs' Annual Report on Religion, with data unavailable between 1963 and 1967.[6]

Table 1 presents the descriptive statistics. The dataset for kindergarten and nursery school attendance rates, which we employ in our analysis, spans from 1957 to 1987. This timeframe allows us to relate educational outcomes to measures of preschool attendance twelve years earlier, both in the context of the high school graduation rate equation and the college advancement rate equations.

On average, the attendance rate for kindergartens hovers around 51%, while that for nursery schools is approximately 32%. Notably, a substantial degree of variability is evident in these attendance rates across both time

[6]The Annual Report on Religion is published by the Agency of Cultural Affairs. The data in this report is derived from the results of the Survey of Religion, which is an annual census survey conducted by the MEXT. The primary objective of this survey is to gather fundamental information, including the number of religious groups, the workforce associated with these groups, and the count of believers.

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Outcomes				
High School Graduation Rate (male)	0.872	0.091	0.532	1.112
4-Year College Advancement Rate (male)	0.230	0.068	0.087	0.432
Preschool				
Kindergarten Attendance Rate at 5 (male)	0.507	0.210	0.051	0.961
Nursery School Attendance Rate at 5	0.317	0.170	0.001	0.980
Controls				
Female Ratio	0.510	0.007	0.475	0.524
Instruments				
Religious Corporations at 5 (per 100)	0.093	0.058	0.007	0.361
Religious Corporations at 4 (per 100)	0.093	0.058	0.007	0.361
Gap betw'n target and 3-year lagged kind.rate	0.186	0.185	0.000	0.603
Number of observations		1,164		

Note: For the outcomes and controls, the averages of prefecture-level observations are from 1966 to 1999 for High School Graduation Rate and from 1969 to 1999 for College Advancement Rate. For the preschool variables and the instruments, the numbers are averages of the lagged variables based on the corresponding age. Religious facilities are the sum of corporations of the Christian and the Buddhism. Outcome and preschool variables are for boy except for nursery school attendance rate and the Gap between policy target (i.e., 63.5%) and kindergarten rate at age 2.

periods and regions. For instance, the minimum nursery school attendance rate registers at a mere 0.1%, while the highest reaches an impressive 98%. Kindergartens exhibit a standard deviation in their attendance rate of 0.21, which is notably higher than the corresponding figure for nursery schools at 0.17.

The average high school graduation rate stands at 87%. Nevertheless, we observe significant variations even within this cohort of students with relatively high advancement rates. The lowest high school advancement rate records at 53%, while the highest reaches 111%.[7] Meanwhile, the average college advancement rate to four-year institutions hovers around 24%.

4.2 Fiscal costs of preschools and data for earnings

In this subsection, we elucidate the data used to estimate the rate of returns to preschool education. Our cost and benefit calculations for preschooling draw from a range of information sources. It's important to note that

[7]The maximum number exceeds 100% partly since this is the gross graduation rate that ignores the grade repetition, and there were some high schools which had 4 year programs.

these sources provide aggregate data at the national level, as data at the prefecture-level is not available to calculate costs and benefits.

Our quantification of monetary benefits relies on two national datasets. Firstly, we utilize data from the Basic Survey of Wage Structure (BSWS) that covers the national average wage of employees, encompassing both regular monthly salaries and annual bonuses, segmented by educational attainment and 5-year age groups.[8] Secondly, we calculate the probability of employment by age and educational achievement, employing data from the 1970, 1980, 1990, 2000, 2010, and 2020 Population Census. In cases where data is missing for certain years within the Population Census, we employ simple linear interpolation to estimate these values. These two datasets are instrumental in calculating the expected returns associated with high school and college graduation.

However, it is imperative to acknowledge a limitation in our calculation process. Specifically, we are forced to disregard the wages of non-regular workers and set them to zero. It's worth noting that not all employees hold regular positions, particularly among those with lower educational attainment. Our data sources, including the Population Census, either do not encompass non-regular workers or fail to differentiate them. The direction of any bias arising from this limitation remains unclear, although it may be positive if our assumption leads to an underestimation of the wages for high school dropouts.[9]

To compute the rates of return, we focus on two distinct cohorts. Cohort 1 comprises individuals who graduated from junior high school in 1971 and potentially attended kindergarten or nursery school in 1961 at the age of 5.

[8]The BSWS is an annual survey that targets regular workers employed by businesses with more than nine employees. The age categories in the published tables are "under 17," "18-19," "20-24," "25-29," ..."Over 65."

[9]One may also think that the short-run benefits of childcare use should include its impact on parental labor supply. While there is a large empirical literature on the relationship between childcare availability and female labor force participation, the evidence is mixed. In Japan, for example, Asai et al. (2015) found, using data from 1990 to 2010 and employing a prefecture fixed effect model, the variation in the availability of full-time childcare, which corresponds to nursery school in our study, was not significantly associated with the labor supply of mothers with children under 6. Their findings suggest the presence of crowding out of informal childcare by other family members due to formal care. During the 1960s-70s, informal care was more prevalent than today, suggesting that the impact on employment would have been even smaller. Additionally, as kindergarten programs were typically half-day, the effect on employment was likely to be further minimized. Considering these factors, we have chosen not to incorporate the potential effects on parental labor supply into the benefits of childcare.

Cohort 2, on the other hand, consists of individuals who are 5 years younger than those in Cohort 1. The choice of these two cohorts for our rate of return calculations is a compromise stemming from the lack of wage data beyond age 60 for younger cohorts and the absence of preschool cost data for older cohorts.

Table 2: Description and summary of education cost data

(1) Kindergarten and Nursery School

Variable	Cohort 1	Cohort 2	Data Source
Kindergarten			
Tuition at private kind. (Yen/year) (A)	11,301	23,720	Annual Report of Education Budget*
Entrance fee at private kind. (Yen) (B)	1,541	3,985	Annual Report of Education Budget*
Average enrollment duration (Year) (C)	1.38	1.60	School Basic Survey
Average annual cost for private kind. per child (Yen) (D)	12,419	26,218	(A)+(B)/(C)
Local gov. expenditure for public kind. per child (Yen/year) (E)	17,669	37,651	Survey of Local Educational Expenditure
Private kind. enrollment ratio (F)	0.70	0.74	School Basic Survey
Average annual cost for kind. per child (Yen) (G)	14,005	29,197	Weighted average of (D) and (E)
Average cost of kind. per child (Yen)	19,306	46,581	(G) x (C)
Nursery School			
National gov. subsidy for running cost (1,000 yen) (A)	4,865,265	14,225,967	Social Security Statistics*
Grant rate of running cost subsidy (B)	0.8	0.8	Social Security Statistics*
National government subsidy for facility (1,000 yen) (C)	53,635	313,982	The Ministry of Health and Welfare (1978)*
Grant rate of facility (D)	0.5	0.5	The Ministry of Health and Welfare (1978)*
Total subsidy (1,000 yen)	6,188,851	18,410,423	(A)/(B) + (C)/(D)
Total enrollment	752,293	847,595	Values for 1971 cohort is an estimate
Total subsidy per child. (Yen) (F)	8,227	21,721	Report on Social Welfare Admin. and Services*
Tuition (Yen) (G)	4,113	10,860	Zenhoren (1976)*
Total cost per child (Yen) (H)	12,340	32,581	(F) + (G)
Average enrollment duration (Year) (I)	1.92	1.92	National Budget, Min. of Health and Welfare*
Average cost of nursery school per child (Yen)	23,656	62,457	(H) x (I)

Note: Cohort 1 (2) is the birth cohort with age 5 in 1961 (1966). Fiscal year for preschool budget is 1961 (1966) for Cohort 1 (2). Annual Report of Education Budget: "Annual Report of Education Budget of National and Local Governments." Social Security Statistics: "National Budget, Annual Report on Social Security Statistics." The data since 1965 for National government subsidy for nursery school facility and the grant rate of nursery school facilities are based on Ministry of Health and Welfare (1978), and the values prior to 1965 are assumed as 10 of the total amount for child welfare facilities. In the calculation of total subsidy for nursery school per child, additional subsidy from local government is ignored. Nursery school tuition is assumed as 50% of the subsidy running cost subsidy based on the value in 1976, which was 53% based on Zenhoren (1976). Average enrollment duration is calculated based on the statistics from National Budget and The Ministry of Health and Welfare (1978), The Ministry of Health and Welfare (1988), and The Ministry of Health and Welfare (1998). The oldest available statistics of the average enrollment duration for nursery schools is 1966 and use the same value for 1961. For the total subsidy for nursery school per child, we ignored additional subsidy from local government.

Table 2: Description and summary of education cost data-*cont.*

(2) High School and 4-year college

Variable	**Cohort 1**	**Cohort 2**	**Data Source**
High School			
Public expenditure for public high school	156,451	352,737	Survey of Local Educational Expenditure, Suetomi (2010)
Tuition at public high school (Yen)	75,570	128,101	Survey of Local Educational Expenditure, Suetomi (2010)
Public expenditure for private high school (Yen)	14,119	68,453	Suetomi (2010)
Tuition at private high schools (Yen)	72,242	187,562	Suetomi (2010)
Private high school enrollment ratio	0.31	0.31	School Basic Survey
Average cost of high school education per child (1,000 Yen)	187.12	414.28	National Budget, Suetomi (2010)
4-year College			
Public Expenditure for national universities (Yen)	1,505,191	2,325,134	National Budget, Suetomi (2010)
Average tuition at national university (Yen)	41,333	147,8,6	National Budget, Suetomi (2010)
Public expenditure for private universities (Yen)	53,728	158,724	Suetomi (2010)
Average tuition at private university (Yen)	172,841	422,710	Suetomi (2010)
Private university enrollment ratio	0.76	0.76	School Basic Survey
Average cost of university education per person (1,000 Yen)	538.57	1042.54	National Budget, Suetomi (2010)

Note: Cohort 1 (2) is the birth cohort with age 5 in 1961 (1966). Fiscal year for high school cost is 1971-73 (1976-79) for Cohort 1 (2). Fiscal year for 4-year college cost is 1974-77 (1979-82) for Cohort 1 (2). The table reports the high school costs for 1971 (1976) fiscal year for Cohort 1 (2) and the 4-year college costs for 1974 (1979) fiscal year for Cohort 1 (2). In the calculation of the average cost of university education per person, the cost of local public universities is assumed to be the same as national universities.

The measures of education costs, encompassing kindergarten, nursery school, high school, and college, are summarized in Table 2, presented separately for Cohorts 1 and 2. For kindergarten costs, we utilize data from the Annual Report of Education Budget of National and Local Government (Kuni to Chiho no Bunkyo Yosan), which covers private kindergarten tuition and entrance fees paid by parents, as well as subsidies from the national government to private kindergartens. It is plausible that local governments may have also provided subsidies to private kindergartens, but a lack of data prevents us from explicitly incorporating this in our calculations. For high school and college attendance, we account for both direct and indirect costs. Direct costs encompass the per-student high school expenditure and four-year college expenditure, calculated as the weighted average of both public and private schools, with enrollment ratios serving as weights. All costs and benefits are deflated to the 2010 Yen for consistency. Appendix B provides further details of the data and variables used in the analysis.

5 Effects of preschooling on educational attainments

This section presents the primary estimation results based on Equation (1). We provide estimates using both Ordinary Least Squares (OLS) and Instrumental Variable (IV) methods. The IV estimations are conducted using the General Method of Moments (GMM) with an optimal weighting matrix. In the GMM framework, we employ the following variables as excluded instruments for the kindergarten enrollment rate, nursery school enrollment rate, and real Gross Domestic Expenditure (GDE) per capita for the same year as the outcome variable: the number of religious corporations (Christian and Buddhist) per 100 members of the population, the one-year lag of the same variable, real GDE per capita for the same year as the preschooling variables, and the kindergarten enrollment rate from the previous year.[10]

Table 3 reports the coefficient estimates in the regression equation. The upper panel comprises three columns displaying the results for the high school graduation rate. The first column presents the results using OLS,

[10]In OLS, standard errors are robust to heteroskedasticity. In GMM, standard errors are heteroskedasticity- and autocorrelation-consistent (HAC: Newey and West (1987)) using Bartlett kernel with band-width 3=T1/3 (Li and Racine (2006), p.405).

Table 3: Estimation results of the effects of preschools on educational achievement

	OLS	IV(1)	IV(2)
Dependent Variable: High School Graduation			
Kindergarten attendance rate	0.241***	0.251***	0.253***
	(0.055)	(0.046)	(0.065)
Nursery School attendance rate	0.241***	0.971***	0.971***
	(0.068)	(0.096)	(0.126)
Female ratio	0.649	0.612	0.600
	(0.623)	(0.519)	(0.596)
R-squared	0.772	0.602	0.602
C-D (or K-P) Statistics for weak IV		77.38	37.40
P-value for Overidentification test		0.824	0.804
Number of Observations		1,164	
Dependent Variable: 4-Year College Advancement			
Kindergarten attendance rate	0.057	0.081***	0.082***
	(0.035)	(0.021)	(0.030)
Nursery School attendance rate	0.062**	0.326***	0.329***
	(0.030)	(0.045)	(0.064)
Female ratio	0.398	0.338	0.315
	(0.328)	(0.241)	(0.278)
R-squared	0.767	0.838	0.837
C-D (or K-P) Statistics for weak IV		77.38	37.40
P-value for Overidentification test		0.222	0.200
Number of Observations		1,164	

Note: Year fixed effects are included. IV(1) is the GMM estimate with prefecture fixed effects. IV(2) is the GMM-HAC estimate with prefecture fixed effects. Robust standard errors are reported in the parenthesis. *** 1%, ** 5%, * 10%.

the second using GMM with prefecture fixed effects, and the third using GMM-HAC with prefecture fixed effects. All findings indicate that preschool expansion positively impacts the high school graduation rate. The coefficient for the kindergarten attendance rate is 0.241 using OLS, 0.251 and 0.253 using GMM and GMM-HAC with prefecture fixed effects, respectively. All these coefficients are statistically significantly different from zero. The IV coefficients suggest that a one-percentage-point increase in the kindergarten attendance rate results in approximately a 0.3 percentage point increase in the high school graduation rate.

Similarly, the coefficient for the nursery school attendance rate is 0.241 using OLS, and 0.971 using GMM and GMM-HAC with prefecture fixed effects. Again, all these coefficients are statistically significantly different from zero. These IV coefficients indicate that a one-percentage-point increase in the nursery school attendance rate leads to roughly a 0.9 percentage point

increase in the high school graduation rate.

The lower panel of the table reports results for the four-year college advancement rate. Coefficients for the nursery school attendance rates are consistently positive and statistically significantly different from zero, regardless of the estimation method. The magnitude of the coefficients varies between 0.062 and 0.329. The coefficients for the kindergarten attendance rate are statistically significant under GMM and GMM-HAC with prefecture fixed effects but not under OLS.

The coefficients obtained using GMM are larger than those using OLS, indicating that OLS underestimates the effects of preschooling on educational outcomes, possibly due to attenuation bias stemming from measurement errors in the preschooling variables. The larger bias in the estimates of the coefficients for nursery school attendance rate compared to the kindergarten rate may be attributed, in part, to larger measurement errors in the construction of nursery school attendance rates. Another contributing factor could be that the effects of preschooling on the population segment affected by the expansion of kindergarten and/or nursery schools provided by religious institutions and/or induced by policy may be larger than on the average population.

Regarding the validity of instruments in the GMM, Table 3 presents the F-test results for the excluded instruments in the first-stage regression, indicating a strong rejection of their insignificance across all specifications. Furthermore, the over-identification test results for instrument exogeneity consistently support the exogeneity of these instruments. Therefore, we conclude that our instruments are valid, and our estimates are suitable for calculating the rate of returns to preschooling in the subsequent section.

6 Estimation of the rate of returns to preschool education

In this section, we present the calculated internal rates of return for the two types of preschool education in Japan, namely, kindergartens and nursery schools. The internal rate of return (hereafter, IRR) allows us to compare the efficiency of alternative educational investments in the same measurement unit. For each Cohort 1 and 2, we construct a national average lifecycle earnings profile up to age 65 for 4-year college graduates, high school

Table 4: Internal rates of return to preschool attendance: Benchmark estimates

Benchmark	IRR of Kindergarten	IRR of Nursery School
OLS		
Cohort 1 (Age 5 in 1961)	7.27%	7.40%
Confidence Interval	[5.82%, 7.71%]	[6.15%, 7.75%]
Cohort 2 (Age 5 in 1966)	6.70%	6.65%
Confidence Interval	[4.67%, 7.37%]	[4.78%, 7.26%]
FE-IV/HAC		
Cohort 1 (Age 5 in 1961)	7.46%	8.07%
Confidence Interval	[6.98%, 7.70%]	[7.98%, 8.14%]
Cohort 2 (Age 5 in 1966)	6.98%	7.91%
Confidence Interval	[6.28%, 7.36%]	[7.73%, 8.04%]

graduates, and individuals who completed only junior high school, using the data described in Section 4.2.[11] We also calculate the costs of education, incorporating forgone earnings and direct costs associated with each level of education. We then determine the discount rate that equates the present values of the benefits and costs for each cohort and preschool education type. For the education effect parameter, we rely on the estimates obtained using FE/GMM-HAC, as we consider them the most reliable, although we also use the other estimates as robustness checks.

Table 4 presents the estimates of the rate of returns to kindergarten and nursery schools for Cohorts 1 and 2, based on the estimates using OLS and FE/GMM-HAC from the previous section. We compute 95% confidence intervals using the lower values of the 95% confidence intervals for the coefficient estimates on high school graduation and 4-year college attendance from Table 3. The results indicate that the point estimates of the IRR fall between 6.6% and 8.1% under FE/GMM-HAC. Notably, the IRR for nursery school is generally higher than the IRR for kindergarten, consistent with the coefficient estimates in Table 3. This finding is striking as it suggests that nursery school is more productive than kindergarten in terms of education

[11] Here, we assume that using the 4-year college advancement rate for its graduation rate does not significantly bias our estimates, although it is challenging to assess the potential bias due to the lack of official data on college dropout rates during the 1970-1980s.

Table 5: Sensitivity analyses of rates of return to preschool attendance

(1) With deadweight loss (10%)

Benchmark	**IRR of Kindergarten**	**IRR of Nursery School**
Cohort 1 (Age 5 in 1961)	7.40%	8.05%
Confidence Interval	[6.89%, 7.65%]	[7.95%, 8.12%]
Cohort 2 (Age 5 in 1966)	6.88%	7.87%
Confidence Interval	[6.15%, 7.27%]	[7.68%, 8.00%]

(2) With deadweight loss (10%) and add. costs for local government (20%)

Benchmark	**IRR of Kindergarten**	**IRR of Nursery School**
Cohort 1 (Age 5 in 1961)	7.26%	8.01%
Confidence Interval	[6.71%, 7.54%]	[7.90%, 8.08%]
Cohort 2 (Age 5 in 1966)	6.67%	7.77%
Confidence Interval	[5.90%, 7.09%]	[7.57%, 7.91%]

production, even after accounting for the endogeneity of the choice of early childhood education and the average years of enrollment. Even considering the wide confidence intervals, which are not necessarily balanced due to the nonlinearity involved in the computation, the values of IRRs are notably high when compared with the average returns on physical assets in Japan over the past 30 years. Moreover, the IRRs based on the FE/GMM-HAC estimates tend to be higher than those based on the OLS estimates due to the possible presence of measurement error bias in the OLS estimates, as discussed in section 5.

Next we conduct several sensitivity analyses. First, we consider the effect of potential deadweight loss (DWL) due to financing preschool education through income tax. We assume that the DWL is 10% of the total costs for preschool education based on Bessho and Hayashi (2013).[12] Then, we additionally consider the possibility of underestimating the social costs of preschool education, as discussed in Section 4.2, especially because the historical government documents lack information about the additional sub-

[12]We are grateful to the suggestion from Shun-ichiro Bessho on the recommended value of DWL.

sidy from municipality offices to private and public nursery schools. This underestimation may arise from a lack of historical government documents, as well as potential general measurement errors associated with estimating the direct costs of education. Table 5 presents the results of sensitivity analysis considering these two possibilities.

Table 5 (1) displays the results under the assumption that the social costs of preschool education are 10% higher due to the DWL. These results reveal that the effects of DWL are very small, causing only a 0.04 to 0.10% point reduction in IRRs. Table 5 (2) shows the results under the additional assumption that the total social costs of preschool education are 20% higher. Under this assumption, the IRRs become 0.06 to 0.31% point lower than the original estimates in Table 4, with the lowest IRR within the 95% confidence interval at 5.90% for kindergarten attendance for Cohort 2. However, all point estimates remain above 6%, significantly higher than the average return on physical assets in Japan.[13]

7 Concluding remarks

This research presents a novel assessment of the rate of return associated with early childhood education, drawing from a comprehensive analysis of the nationwide expansion of preschool education in Japan during the period from 1960 to 1980. By utilizing panel data at the prefecture-level, we initially investigate the impact of the widespread increase in preschool enrollment on two key indicators of educational attainment: high school graduation rates and the percentage of students advancing to 4-year colleges. Subsequently, we employ national wage statistics and government records on preschool costs to calculate the social rate of return to preschool attendance. Our

[13]For a more comprehensive robustness check, we estimated Model 1, allowing for the incorporation of sample weights based on preschool enrollment at age 5, as well as clustering of errors at the prefecture-level. When introducing the weights, the estimated IRRs ranged from 7.11% to 8.17%. Furthermore, with the additional introduction of clustering, the point estimates ranged from 7.09% to 8.15%, with statistical significance for kindergarten. We also considered the potential presence of severe aggregation bias due to the nature of our prefecture-level dataset. According to Hanushek et al. (1996) and Fertig and Wright (2005), aggregation bias in the estimation of the education production function is likely to overestimate the effect of schooling. We assumed that a substantial positive aggregation bias existed in the first stage estimation and that the true coefficients based on individual data would be half of our estimated values. Even under this assumption, the calculated IRRs based on the point estimates (as the standard error would also change with individual data) still ranged between 5.71% and 7.88%.

findings reveal a range of 5.7% to 8.1% for the social rate of return.

Notably, our estimated values for the Internal Rate of Return (IRR) to preschool education in Japan closely align with those put forth by Heckman et al. (2010b). As highlighted by Duncan and Magnuson (2013), it is plausible that the returns on early childhood education have seen a gradual decline over the years. The resemblance between our estimates and those presented in Heckman et al. (2010b) can be seen as generally consistent with this prevailing trend. Furthermore, there are potentially two key factors contributing to the larger rate of return to nursery school compared to kindergarten. These factors include the extended duration of nursery school programs and their full-time nature. Our analysis, comparing the IRRs of nursery school and kindergarten, reaffirms the effectiveness of the former even when considering the comprehensive program costs. We believe that further research in this direction is pivotal to elucidating the underlying mechanisms that generate these different returns in early childhood education.

While our rate of return estimates demonstrate robustness through a battery of sensitivity analyses, our study is subject to several limitations. We were unable to estimate the non-pecuniary benefits of early childhood education, such as the reduction in criminal activities noted by Heckman et al. (2010b). Despite Japan's notably lower homicide rate compared to the United States (0.2 in 100,000 people in Japan and 5.8 in the U.S. in 2019 based on OECD Statistics), making the impact of crime reduction in the Japanese context seemingly negligible, exploring the influence of early education on non-monetary benefits remains an essential avenue for future research. Additionally, although we exclusively focused on the rate of return for men due to the challenges associated with estimating long-term monetary benefits for women with weaker labor market attachment in Japan, investigating the internal rate of return for women is a significant and necessary area for further exploration. Lastly, Japan has notable social benefits tied to poverty prevention and welfare reduction, leaving the substantial consideration of social benefits for future investigations.

Appendix A First stage results

Table A. Estimation results of the first-stage regression

Variables	**Kindergarten**	**Nursery School**
Religious Corporations at 5	-0.142	0.880
	(0.325)	(0.711)
Religious Corporations at 4	-0.340	1.174
	(0.324)	(0.723)
Gap between target and 3-year lagged kind. rate	-0.846***	0.065
	(0.021)	(0.040)
Female Ratio	0.371*	0.277
	(0.224)	(0.505)
Number of Observations	1,164	

Note: The estimates with prefecture fixed effects are reported. Year fixed effects are included. Standard errors robust to heteroskedasticity and autocorrelation with Bartlett kernel (bandwidth= 3) are reported in the parenthesis. *** 1%, ** 5%, * 10%.

Appendix B Details of IRR calculation

B.1 Cost calculation

B.1.1 Social cost of preschool

Due to data limitations, we calculated the costs of nursery schools and private kindergartens from the revenue side, while the costs of public kindergartens were calculated from the expenditure side.

Average annual cost per child in kindergarten

(1) To obtain the annual total cost per child for private kindergartens, we summed the average tuition fees for private kindergartens in 1961, as reported in the "National and Local Education Budgets Each Year" from the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). We also included the national and local subsidies per child for private kindergartens from the same source. The initial registration fee (Nyuenryo) was divided by 2 to represent the one-year cost, as most kindergartens offered a two-year program, and this cost was factored into the total annual cost.

(2) For public kindergartens, we calculated the annual per child expenditure using the "Local Education Expenditure Survey" provided by MEXT.

(3) Finally, the average cost of kindergarten was computed as a weighted

average of the costs for private and public kindergartens, based on the ratio of children enrolled in each type of kindergarten.[14] This was multiplied by the average years of kindergarten enrollment, which we estimated from enrollment statistics, to obtain the total average social cost of kindergarten enrollment.

Average annual cost per child in nursery school

(1) Due to the lack of data, to estimate the total number of children enrolled in nursery schools for each year before 1966, we divided the number of 5-year-olds enrolled in nursery schools for each year by the ratio of 5-year-olds in nursery schools in 1966. The cost of establishing nursery schools was obtained from government statistics, specifically "Social Welfare Facility Equipment Expenses" from the Ministry of Health, Labor, and Welfare (MHLW) for the year 1966 and onwards. For years prior to 1966, we assumed that 10% of the total expenses for "Child Welfare" from "Social Welfare Facility Equipment Expenses" was allocated to nursery schools based on the ratio in 1966.

(2) The government administrative cost per child in nursery schools, referred to as "Sochihi," was calculated using government statistics.

(3) The fees paid by parents at nursery schools were estimated to be 50% of the total governmental cost, based on a typical municipality. The total social costs for nursery schools were derived as the sum of governmental costs and parental fees. However, it's important to note that this estimation does not account for local government subsidies for childcare fees, among other factors.[15] We then multiplied the average years of nursery school enrollment, estimated from government statistics in 1966 (the earliest available record), by the annual cost to determine the total average social cost of nursery school enrollment.

[14] Tuition fees for public kindergartens are disregarded as being reflected in municipal spending. However, subsidies to private kindergartens provided by the municipality are not taken into account.

[15] Essentially, it is difficult to assume that both kindergarten and preschool children attend school only at age 5, and it is necessary to reflect the ratio of children attending school at ages 3-4 and the cost of childcare in 1960-1959. However, due to data limitations, this is difficult to do, so data from 1961 is used as an approximation.

B.1.2 Social cost of high school and 4-year college

Education expenditures for high school and college were sourced from Table 2-4 (pages 87-92) in Suetomi (1998). We made the assumption that children of Cohort 1, who were 5 years old in 1961 and graduated from junior high school in 1971, attended high school and 4-year college during the periods of 1971-73 and 1974-1977, respectively. We applied a similar assumption to children of Cohort 2, who were 5 years old in 1966.

To calculate the social cost per student per year for high school and 4-year college, we used the public education costs provided by Suetomi (1998) and the enrollment figures for national, public, and private schools obtained from the Basic School Survey. The calculations were as follows:

Social cost per student per year of high school = (nominal cost of public high school education + nominal tuition fees) x public and national high school enrollment rate + (nominal public subsidy for private high schools + nominal tuition fees) x private high school enrollment rate.[16]

Social cost per student per year of 4-year college = (nominal government expenditure for national universities + nominal tuition and fees) x public university enrollment rate + (nominal government subsidy for private universities + nominal tuition and fees) x private university enrollment rate.

Regarding the deadweighted cost of taxation, similar to the approach in Heckman et al. (2010b), we considered the income tax financing costs of education and assumed a deadweight of 10% for Japan, based on findings from Bessho and Hayashi (2013).

B.2 Calculation of earnings

We utilized data from the "Basic Survey of Wage Structure" (The Statistics Bureau of Japan) to compute annual earnings within specific 5-year age categories and educational attainment levels. Initially, we extracted the average monthly cash salary of regular workers (including part-time workers before 1969) in businesses with 10 or more employees, categorized by education, gender, and 5-year age groups. To establish annual average earnings, we multiplied the monthly salary by 12 and then added the "annual bonus and other special salary." Annual earnings were recorded as zero during ages

[16] Although public expenditures for national high schools may be higher than those for public high schools, they can be ignored because the number of students enrolled is less than 0.3% of that for public high schools.

corresponding to enrollment in school, specifically from ages 16 to 18 for high school graduates and from ages 19 to 22 for 4-year college graduates.

For the employment rate by age group, we sourced data from the 1970-2020 Census, which tabulated labor force statistics, including employed, unemployed, and non-labor force individuals, at 10-year intervals based on age and the last level of education completed (junior high school, high school, 2-year college, or 4-year college). Using this dataset, we calculated the employment rate, defined as the ratio of employed individuals to the total population, based on the last level of education completed. For years without survey data, we conducted linear interpolation (for years prior to 1970) and extrapolated missing data by using the same ratio as that observed in the 1970-80 period.

Subsequently, we determined the difference in the average annual compensation multiplied by the employment rate between 4-year college graduates and high school graduates, as well as between high school graduates and junior high school graduates.[17] With this information, coupled with the direct costs of high school and 4-year college education, we constructed a net return profile for the cohort of interest.

Figures B.1 and B.2 illustrate the net return profiles (i.e., nominal earnings net tuition) for Cohort 1 (Age 5 in 1961) and Cohort 2 (Age 5 in 1966), respectively.

B.3 Calculating the rate of return

To determine the discounted sum of present value returns, we deflate the nominal net returns using the consumer price index and discount them by applying the discount rate, which will be established at a later stage. or these calculations, we rely on the coefficient estimates obtained from the GMM-HAC results for high school graduation and college attendance, as presented in Table 3, specifically in IV(2). These coefficients are instrumental in calculating the rate of return associated with an increased probability for a child to enroll in kindergarten or nursery school at age 5 through fiscal expansion.

[17] Although we did not consider 2-year college, such as the junior colleges and technical colleges, separately from high school graduates, we believe that its effect on the estimates is negligible since the share of attendants of these 2-year colleges were extremely low for men.

Figure B.1: Net return profile for Cohort 1 (Age 5 in 1961)

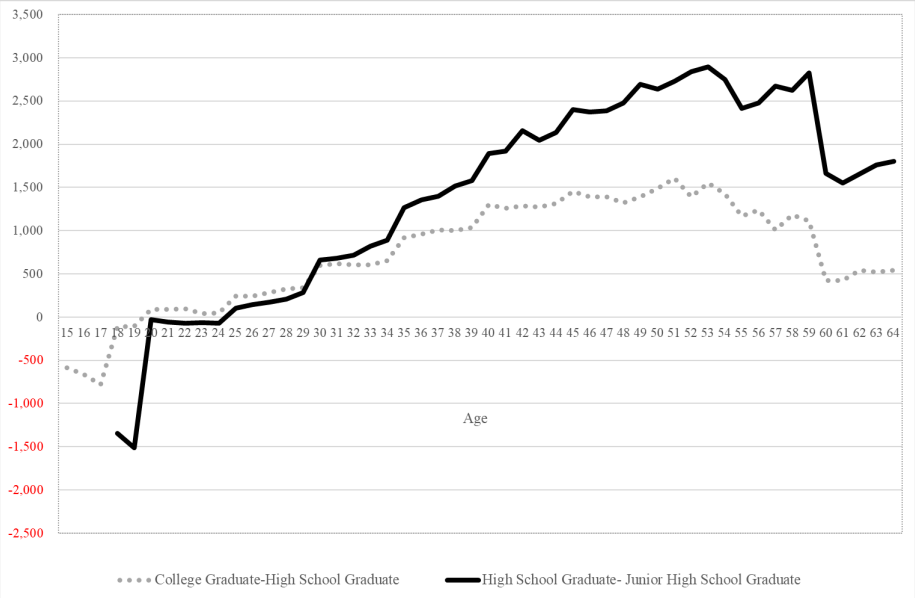
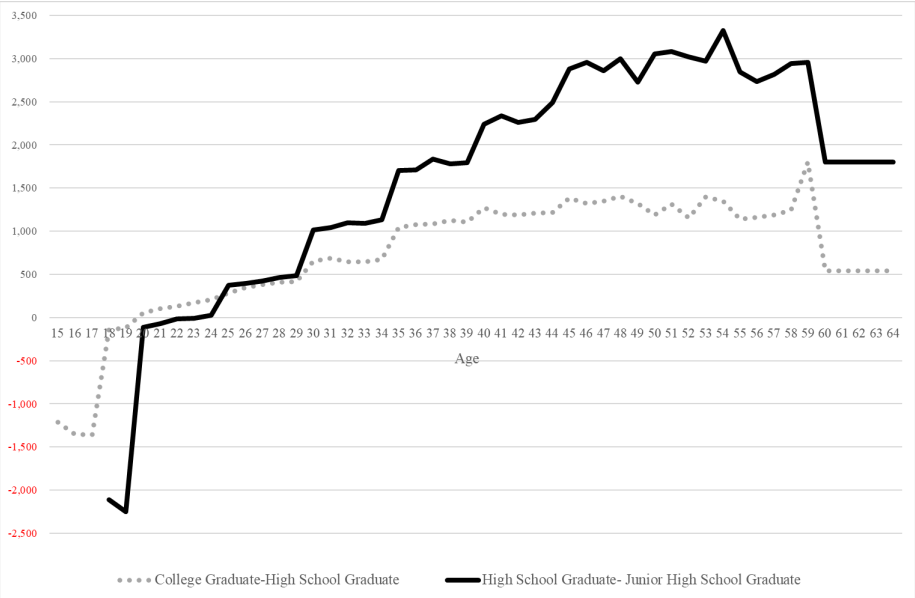


Figure B.2: Net return profile for Cohort 2 (Age 5 in 1966)



Once the discount factor, denoted as beta, is established, we can proceed to compute the discounted sum of present value returns. Subsequently, we determine the value of beta that ensures this sum is equal to zero.

Appendix C The validity of using prefecture-level data

In this section, we provide detailed justification for our approach using prefectural average data, considering the institutional settings of Japan and evidence from additional sources.

1. Japan's School Education Law prohibits early school enrollment. While school authorities may allow parents to delay their child's enrollment under specific circumstances, such as serious health and developmental problems, the number of children delaying enrollment has been extremely low. According to the School Basic Statistics, the number of elementary school-aged children who delayed enrollment was 14,946 in 1961 and 10,953 in 1966. Relative to the grade 1 enrollment figures for those years, these delayed enrollments accounted for only 0.89% in 1961 and 0.70% in 1966. Therefore, there is minimal risk of potential estimation bias resulting from disregarding delayed or early school enrollments.

2. Under Japan's School Education Law, grade repetition is not permitted (OECD, 2011).

3. We acknowledge that we assumed that the enrollment rate at age 5 is perfectly correlated with the enrollment rates at earlier ages to simplify our calculations. To justify this assumption, we calculated the correlation between the enrollments at different ages of children across prefectures in 1961 and 1966. The correlation coefficients were generally very high, ranging between 0.912 and 0.977 for ages with a one-year difference and between 0.786 and 0.829 for ages with a two-year difference, supporting our approach. Unfortunately, similar statistics are unavailable for nursery school enrollment rates.

4. Migration across prefectures was very rare in the 1960s-70s. According to The National Survey on Migration in 1976 (The Institute of Population Problems, 1977), among individuals under age 20 in 1976 (equivalent to the cohort aged 5 or younger in 1961), 87% of men attended elementary school in their birth prefecture, and 88% attended high school in the prefecture of

their elementary school. This suggests that nearly 80% of preschool children attended high school in the same prefecture. Given the low migration rate before high school and limited availability of information on preschool options in the 1960s-70s, it is unlikely that parents moved between prefectures based on their educational preferences, and therefore, we believe that disregarding inter-prefectural migration before high school age does not severely bias our estimates. Kawarazaki (2022) also supports this view.

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