The Effect of Early Childhood Programs on Third-Grade Test Scores: Evidence from Transitional Kindergarten in Michigan*

By JORDAN BERNE, BRIAN JACOB, TAREENA MUSADDIQ, ANNA SHAPIRO, AND CHRISTINA WEILAND†

Early childhood education (ECE) programs boost children's school readiness and can have long-run effects on participants' educational, income, and health outcomes (Phillips et al., 2017). Transitional Kindergarten (TK) programs are a relatively new entrant into the early education landscape, having come about as states pushed back the dates at which children can enter traditional kindergarten. Unlike many public early education options, TK programs are not targeted to children from families with low income. They also differ from many public ECE options in other important ways: TK operates only in public schools, is taught by state-certified teachers who are paid at the level of other K-12 educators, and tends to use a more academic-focused curriculum than many ECE programs (Shapiro et al., 2023).

The only TK program rigorously evaluated is the statewide program in California. Manship et al. (2017) found the program increased students' early literacy, language, and math skills along with kindergarten engagement. However, a study with a larger sample followed via administrative records found no benefits of TK on student's 3rd and 4th grade test scores (Lafortune and Hill, 2023).

We extend this literature by estimating the impacts of Michigan's TK program. In Michigan, TK funding is available for all children who turn five by the state's kindergarten birthday cutoff (September 1) or within three months after (September 2-December 1). Therefore, funding is available for all five-year-olds, but only the oldest four-year-olds. Hence, families of children who turn five *after* the state's September 1 kindergarten cutoff but *on or before* December 1 have three options: 1) enroll in TK (in districts that offer it and in which there is space); 2) waive into traditional K early (in all districts); or 3) choose an alternative public or private care setting, including staying home.

Leveraging the December 1 age-eligibility cutoff in a regression discontinuity (RD) framework, we find substantial positive impacts of attending TK on children's 3rd grade math and English Language Arts (ELA) test scores.

I. Data

This study uses longitudinal administrative data on the universe of Michigan public school students. Unfortunately, not every school district in Michigan has reliable data on TK enrollment. Therefore, we restrict our sample to districts that do not offer TK and districts with TK that reliably report student-level enrollment. For more information on how we identify districts with reliable data, and how these districts compare to those with unreliable data, see Appendix A.

We also limit our sample to students who turned five near December 1 in 2014 or 2018. (We exclude students in the intervening cohorts because their 3rd grade tests were disrupted by the COVID-19 pandemic.) Our other data cleaning decisions and sample restrictions are detailed in Appendix A.

* Go to https://doi.org/10.XXXX/pandp.2024XXXX to visit the article page for additional materials.

† Berne: University of Michigan (email: jsberne@umich.edu). Jacob: University of Michigan (email: bajacob@umich.edu). Musaddiq: Mathematica Inc. (email: tmusaddiq@mathematica-mpr.com). Shapiro: RAND Corporation (email: ashapiro@rand.org). Weiland: University of Michigan (email: weilandc@umich.edu). The data used for this research was structured by the MERI-Michigan Education Data Center (MEDC), and is not identical to data collected and maintained by the Michigan Department of Education (MDE) or Michigan's Center for Educational Performance and Information (CEPI). Results and opinions presented here do not reflect the views or positions of MDE or CEPI. This research was funded by the Smith Richardson Foundation, as well as training grants R305B20011 and R305B170015 from the U.S. Department of Education's Institute of Education Sciences. We thank MDE and CEPI for their partnership, especially Thomas Howell and Richard Lower. We also thank Katia Cordoba Garcia and Samuel Owusu for excellent research assistance and Jasmina Camo-Biogradlija for assistance with data agreements and project management.

TABLE 1—SUMMARY STATISTICS

	Non-TK Districts		TK Districts		
	All Students	Early K Students	All Students	Early K Students	TK Students
Female (%)	50	56	50	57	50
White (%)	48	33	74	63	77
Black (%)	36	51	12	18	11
Hispanic (%)	10	9	7	7	7
Economically disadvantaged (%)	70	76	46	56	38
Neighborhood median household income ($)	49,666	45,951	66,494	61,976	69,120
Charter school (%)	30	46	3	4	5
District is in city (%)	40	49	21	35	19
District is in suburb (%)	29	32	54	49	57
District is in rural area (%)	23	13	13	7	13
District mean 3rd grade math score (SD)	−0.264	−0.339	0.249	0.191	0.231
Observations	9,902	8,410	2,043	923	1,689

Note: "Early K" students are those who use a waiver to enroll in regular kindergarten despite turning five after the kindergarten birthday cutoff. We use the sample of students born within 30 days of the TK cutoff to construct these statistics. All statistics are calculated at the student level. See Appendix A for a summary statistics table with a larger set of characteristics.

As Table 1 shows, students in TK districts were more likely to be White, less likely to be economically disadvantaged, and more likely to live in suburbs. Compared to other students in the same district, TK students tended to be slightly more economically advantaged and more likely to live in a suburb. For more information on the districts with TK programs and the students who choose to participate, see Shapiro et al. (2023).

II. Empirical Strategy

Identification in this setting is challenging because at the cutoff (December 1), children not only become eligible for TK but also gain the ability to enter kindergarten early via a waiver (we denote students who choose to enter kindergarten early as EK). With the standard RD assumptions, we can only identify the combined effect of becoming eligible for *both* TK and EK.[1] Decomposing this intent-to-treat (ITT) effect into separate TK and EK effects requires more structure.

[1]To economize on space, we present results from the usual RD validity checks in Appendix C. A couple results raise concerns, but overall we believe we have a valid natural experiment.

As we show in Appendix B, the ITT effect for TK districts is a weighted combination of the TK and EK local average treatment effects (LATEs):

$$ITT = \Omega_{TK} LATE_{TK} + \Omega_K LATE_{EK} \quad (1)$$

where each Ω_x weight is the share of students at the cutoff who are compliers for option x. Notice that the quantities ITT, Ω_{TK}, and Ω_{EK} are all identified simply using districts that offer TK.

At this point, we have one equation with two unknowns: $LATE_{TK}$ and $LATE_{EK}$. Intuitively, since the ITT effect is a combination of two unobserved LATEs, recovering one of the two would allow us to back out the other. Our strategy is to use districts that do not offer TK as a second source of information to recover the LATE for the early K treatment.

In districts without TK, the RD cutoff generates variation in early K entry but not TK enrollment, allowing us to cleanly identify $LATE_{EK}$. However, using non-TK districts to infer $LATE_{EK}$ in TK districts requires some type of restriction on treatment effect heterogeneity. In theory, $LATE_{EK}$ may differ across districts. As we showed in Table 1, early kindergarten students in TK and non-TK districts differ on observable characteristics, and they likely differ in

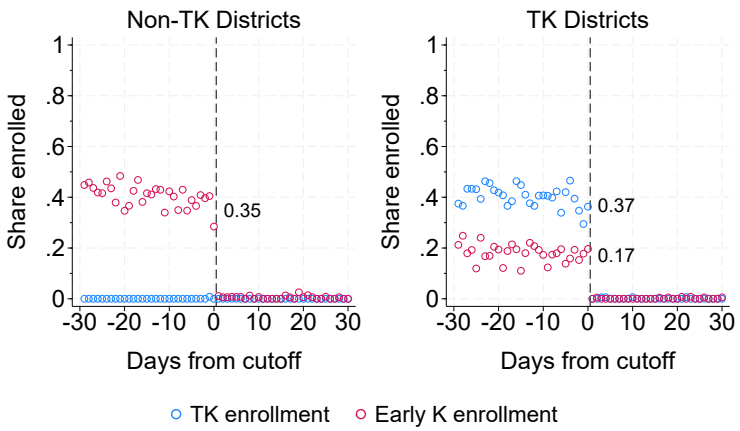


FIGURE 1. FIRST STAGE EFFECTS ON TK AND EK ENROLLMENT IN ONE'S PRE-K YEAR

unobservable ways too. We take two approaches to estimation in order to address the potential for treatment effect heterogeneity.

A. *Baseline Estimation Approach*

In our baseline approach, we assume the treatment effect of TK is the same in TK and non-TK districts, and estimate $LATE_{TK}$ and $LATE_{EK}$ jointly using both TK and non-TK districts. For student i in district d from cohort c, we estimate the following system of equations via two-stage least squares (2SLS):

$$Y_i = \beta_0 + \beta_1 TK_i + \beta_2 EK_i + f(dob_i) + \Pi \mathbf{X}_i + \lambda_{dc} + \varepsilon_{idc} \quad (2)$$

$$TK_i = \delta_0^{TK} + \delta_1^{TK} Left_i + \delta_2^{TK} Left_i \times DistHasTK_{dc} + f^{TK}(dob_i) + \Psi^{TK}\mathbf{X}_i + \theta_{dc}^{TK} + \varepsilon_{idc}^{TK} \quad (3)$$

$$EK_i = \delta_0^{EK} + \delta_1^{EK} Left_i + \delta_2^{EK} Left_i \times DistHasTK_{dc} + f^{EK}(dob_i) + \Psi^{EK}\mathbf{X}_i + \theta_{dc}^{EK} + \varepsilon_{idc}^{EK} \quad (4)$$

where $\mathbf{X}_i$ is a vector that includes student sex, race, and economic disadvantage status; λ_{dc}, θ_{dc}^{TK}, and θ_{dc}^{EK} are district×cohort fixed effects; and dob_i is date of birth. The f functions allow different linear relationships between date of birth and outcomes on either side of the cutoff and across districts with and without TK. The excluded instruments, $Left_i$ and $Left_i \times DistHasTK_{dc}$, indicate being born to the left of the RD cutoff and being left of the cutoff in a district×cohort in which TK is offered. We estimate these equations using a bandwidth of ±30 days. Our estimates for $LATE_{TK}$ and $LATE_{EK}$ are $\hat{\beta}_1$ and $\hat{\beta}_2$, respectively.[2]

B. *Preferred Estimation Approach*

In our preferred approach, we allow $LATE_{EK}$ to differ by student demographic characteristics. To operationalize this idea, we estimate early K effects in the *non-TK sample* separately for 8 demographic cells defined by sex × race (White or Asian vs. other races) × economic disadvantage status (disadvantaged vs. not). We estimate these effects using a 2SLS model analogous to Equations 2 and 4.

Next, within the *TK sample*, we calculate the share of early K students that belong to each of the same 8 demographic cells. We then use these shares as weights to aggregate the cell-specific effects from the non-TK sample. The result is a single $LATE_{EK}$ estimate that reflects the cell-specific treatment effects from the non-TK districts weighted to reflect the demographic composition of early K students in TK districts.

Once we have a "demographically-adjusted" estimate of $LATE_{EK}$, it is straightforward to

[2] As a check on the 2SLS specification, we also estimate the components of Equation 1 separately and back out $LATE_{TK}$. The estimates are nearly identical.

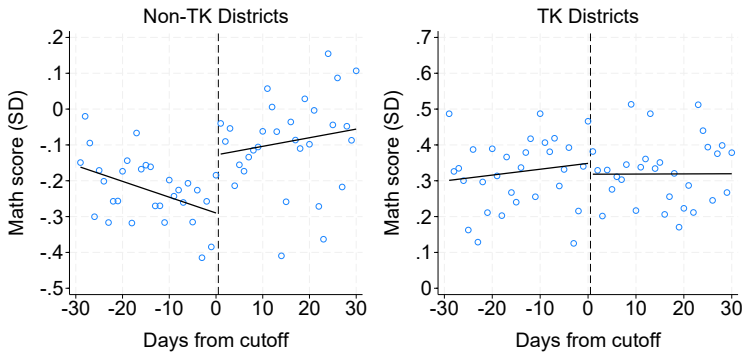


FIGURE 2. INTENT-TO-TREAT EFFECTS ON 3RD GRADE MATH SCORES

back out $LATE_{TK}$ using Equation 1 and estimates of ITT, Ω_{TK}, and Ω_{EK} from the TK sample.

We conduct inference via bootstrap because this approach contains multiple steps. For consistency, we bootstrap in the baseline approach too. See Appendix E for more details.[3]

III. Results

Figure 1 shows we have strong first stage impacts on TK and early K enrollment at the RD cutoff. In non-TK districts, 35 percent of students waive into kindergarten early. In TK districts, 37 percent of students enroll in TK and 17 percent enter kindergarten early.

Figure 2 presents a visual representation of our ITT effects on 3rd grade math scores, which also provides intuition for our estimation of the treatment effects of TK and early K. In non-TK districts, there is a large negative discontinuity at the cutoff. Because early K is the only option associated with the cutoff in these districts, the figure tells us that students who waive into K early score substantially lower on the 3rd grade math exam. This result is not surprising given that early K students take 3rd grade tests one year earlier than they otherwise would, giving them one less year of cognitive development (Deming and Dynarski, 2008). On the other hand, in TK districts—where the cutoff is associated with both K waiving and TK—there is hardly any discontinuity at the cutoff. If early K has a negative effect in TK districts like it does in non-TK districts, this implies TK must have an offsetting positive effect.

Consistent with this visual intuition, the results in Table 2 indicate that TK enrollment leads to substantial improvements in 3rd grade math scores. Our baseline estimate is 0.21 standard deviations and our preferred estimate is 0.29 standard deviations. The reason for the difference is that the demographic subgroups that dominate the early K compliers in TK districts (e.g., White and Asian girls regardless of economic disadvantage and White and Asian boys who are not economically disadvantaged) experience the largest negative effects from attending kindergarten early (see Appendix D). Using our preferred approach, we estimate that TK enrollment increases 3rd grade ELA scores by 0.19 standard deviations, although this estimate is not statistically distinguishable from 0.

Several points are worth noting when interpreting these estimates. First, the TK impacts are relative to a counterfactual of starting kindergarten "on schedule" or later, having spent one's pre-K year receiving care at home, attending Michigan's income-targeted public pre-K program, attending private pre-K, or spending the year in some other type of arrangement. Second, and related, because they reflect the impact for students close to the December 1 cutoff, our estimates capture the effects of TK for children who are among the oldest in their birth cohort.

In Appendices C and D, we conduct RD validity checks and elaborate on our identification strategies.

[3]Table 2 summarizes our inference results with p-values rather than standard errors because the bootstrap distributions in our preferred approach are non-normal and contain extreme outliers, rendering the standard errors uninformative.

TABLE 2—IMPACTS OF TK AND EK ON 3RD GRADE TEST SCORES

	Math				ELA			
	Baseline		Preferred		Baseline		Preferred	
$LATE_{TK}$	0.252**	0.212*	0.331*	0.294	0.123	0.097	0.209	0.191
[P-value]	[0.046]	[0.051]	[0.088]	[0.111]	[0.321]	[0.401]	[0.253]	[0.293]
$LATE_{EK}$	−0.378***	−0.366***	−0.557*	−0.557*	−0.240*	−0.219*	−0.435	−0.435
[P-value]	[0.000]	[0.000]	[0.092]	[0.092]	[0.061]	[0.078]	[0.181]	[0.181]
Controls		X		X		X		X
Control mean		0.302				0.286		
Observations		15,680				15,669		

Note: Inference is conducted via bootstrap, with clustering on the running variable. Appendix E elaborates on our inference strategy. In the preferred approach, we always exclude controls when estimating EK LATEs because the demographic subgroups are defined by the covariates. Hence, the EK estimates in the with- and without-controls columns are identical by construction. The control mean is the average of the outcome variable for students in TK districts born 1-5 days after the cutoff. The first stage F-statistics in the baseline model are 336.21 (math) and 339.82 (ELA) for TK and 400.34 (math) and 340.52 (ELA) for EK. *** p<0.01, ** p<0.05, * p<0.1

IV. Discussion

Research commonly finds that attending preschool has sizable impacts on kindergarten readiness, followed by partial or complete fade out in the early elementary years, and then re-emergence of benefits in early adulthood (Phillips et al., 2017). Our finding that Michigan TK raises 3rd grade math scores stands in stark contrast to this typical pattern.

The magnitude of our estimates is large relative to the prior literature. Across all relatively rigorous evaluations of programs since the 1960s, the average impact of preschool on children's *end-of-preschool* cognitive skills is about 0.25 standard deviations (Duncan and Magnuson, 2013). Our impact estimates are the same size for students in 3rd grade. To give another reference point, our math estimates amount to 57% of expected cognitive development between 3rd and 4th grade (Hill et al., 2008).

The more positive impacts of Michigan TK compared with other ECE programs could be due to a variety of factors, including (a) less formal early childhood education among the control group in our sample, (b) the quality of TK teachers, and (c) better alignment between TK and early elementary schooling. In future work, we will investigate these and other potential mechanisms as well as explore the heterogeneity of treatment effects across subgroups. We hope that our findings will inform the development and scaling of other successful ECE models in Michigan and elsewhere.

REFERENCES

Deming, David, and Susan Dynarski. (2008). "The Lengthening of Childhood." *Journal of Economic Perspectives* 22 (3): 71–92.

Duncan, Greg, and Katherine Magnuson. (2013). "Investing in Preschool Programs." *Journal of Economic Perspectives* 27 (2): 109-132.

Hill, Carolyn, Howard Bloom, Alison Black, and Mark Lipsey. (2008). "Empirical Benchmarks for Interpreting Effect Sizes in Research." *Child Development Perspectives* 2 (3): 172-177.

Lafortune, Julien, and Laura Hill. 2023. "Assessing Transitional Kindergarten's Impact on Elementary School Trajectories." Public Policy Institute of California.

Manship, Karen, Heather Quick, Aleksandra Holod, Nicholas Mills, Burhan Ogut, Jodi Jacobson Chernoff, Jarah Blum, Alison Hauser, Jennifer Anthony, and Raquel González. (2015). "Impact of California's Transitional Kindergarten Program, 2013–14." American Institutes for Research.

Phillips, Deborah, Mark Lipsey, Kenneth Dodge, Ron Haskins, Daphna Bassok, Margaret Burchinal, Greg Duncan, Mark Dynarski, Katherine Magnuson, and Christina Weiland. (2017). "Puzzling it out: The Current State of Scientific Knowledge on Pre-

Kindergarten Effects - A Consensus Statement." The Brookings Institution.

Shapiro, Anna, Jordan Berne, Katia Cordoba Garcia, Brian Jacob, Tareena Musaddiq, Samuel Owusu, and Christina Weiland. (2023). "Michigan Transitional Kindergarten: A First Look at Program Reach and Features." University of Michiga, Education Policy Initiative.