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Effects of Public Preschool Expenditures on the Test Scores of 4th Graders: Evidence from TIMSS

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Abstract

This study examines the effects of public preschool expenditures on the math and science scores of 4th graders, holding constant child, family, and school characteristics, other relevant social expenditures, and country and year effects, in seven Organization for Economic Co-operation and Development (OECD) countries -- Australia, Japan, Netherlands, New Zealand, Norway, U.K., and U.S -- using data from the 1995 and 2003 Trends in International Mathematics and Science Study (TIMSS). Our results indicate that there are small but significant positive effects of public preschool expenditures on the math and science scores of 4th graders and preschool expenditures reduce the risk of children scoring at the low level of proficiency. We also find some evidence that children from low-resource homes and homes where the test language is not always spoken may tend to gain more from increased public preschool expenditures than other children,.

Keywords

Preschool; *Public policy*; *Expenditures*; *Test scores*; *Disadvantaged*

INTRODUCTION

Early childhood education and care (ECEC) has become an important public policy issue in many countries, as policymakers, researchers, and parents have increasingly come to recognize the value of early education for later learning. By 2001, the share of children in preschool the year prior to school entry was near universal in Belgium, France, Norway, Sweden, and the United Kingdom, and approached two-thirds in the United States (Organization for Economic Co-operation and Development (OECD), 2001).

However, countries differ in their approach to whether families or government should bear the cost and responsibility of providing ECEC services. Many European countries consider ECEC a public responsibility and have been moving to universal and free or heavily subsidized ECEC programs for all children regardless of family income or the employment status of parents, while the U.S. continues to rely mainly on family members, employers, and private ECEC programs (Kamerman & Waldfogel, 2005; Smolensky & Gootman, 2003; Waldfogel, 2006a, 2006b). Although overall public investment in ECEC is still relatively low in most countries, with the average expenditure on preschool programs per capita as a percentage of that on primary school programs ranging from 12% to 17% in OECD countries since 1985, spending is substantially lower in the U.S., where the comparable figures are 0.2–0.5% (OECD, 2005a, 2005b).

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Do such cross-country differences in preschool expenditures have consequences for children's school achievement? Although studies in individual countries such as the U.S. have shown short- and long-term positive effects of publicly financed ECEC programs such as Head Start and pre-kindergarten, there is little cross-national evidence on the effects of public preschool expenditures. Ideally, we would like to know if, across countries, preschool expenditures improve school achievement for children on average, as well as whether such expenditures provide a disproportionate boost to children at risk of poor school achievement.

Our study provides some preliminary evidence on these questions by examining whether public preschool expenditures are associated with math and science scores for 4th graders, holding constant child, family, and school characteristics as well as country and year effects. Our analysis makes use of two waves of micro-data from the Trends in International Mathematics and Science Study (TIMSS) in seven OECD countries, supplemented with OECD data on public expenditures in those countries over time on preschool, primary school, and other key social programs for families and children. We also examine whether preschool expenditures matter more for children who may be at risk of poor school achievement, as indexed by having low levels of resources in the home or not always speaking the test language at home.

BACKGROUND AND CONCEPTUAL FRAMEWORK

To justify public expenditures on ECEC, one critical issue for researchers to explore is the effects of such expenditures on school readiness and school achievement. Economic theory suggests that to the extent that public preschool expenditures improve the availability and quality of ECEC programs, this should lead to greater school readiness and school achievement (Heckman & Krueger, 2003). Public expenditures may allow care to be provided to more children and also may improve the quality of care by making it possible to recruit and retain more highly-qualified staff, reduce child/staff ratios, equip sufficient and quality facilities, and maintain an effective support and monitoring system (OECD, 2001). However, additional expenditures may not increase access to care if parents simply substitute publicly provided care for care they would have purchased anyway, and may not improve the quality of care if the publicly provided care is not of better quality than the care children were placed in previously (Blau, 2001).

To the extent that public preschool expenditures increase access to care and possibly the quality of that care, there are several reasons to expect that children from disadvantaged families might benefit more than other children from expansions in public preschool expenditures. First, disadvantaged children might be more likely than more advantaged children to receive no care or inferior quality child care in the absence of public spending. For instance, in the U.S., large disparities in preschool enrollment rates exist between lower-income and higher-income children, and between Hispanic children and non-Hispanic children (Bainbridge et al., 2003; Meyers et al., 2004). Second, disadvantaged children might gain more than other children from a given level of provision. Many studies of preschool have found that the benefits are larger for children who come from more disadvantaged backgrounds than for their more advantaged peers (Magnuson & Waldfogel, 2005).

Although studies in individual countries, in particular the U.S., have shown short- and long-term positive effects of publicly financed ECEC programs such as Head Start (Currie 2001; Currie & Thomas, 1995; Garces, Thomas, & Currie, 2002; Puma et al., 2005) and prekindergarten (Barnett, Lamy, & Jung, 2005; Gormley & Gayer, 2005; Gormley et al., 2005; Magnuson et al., 2004 and in press), there is little cross-national evidence on the effects of public preschool expenditures. We were not able to locate any prior studies that

examined the effects of public preschool expenditures on children's school achievement across countries and over time.

Cross-national studies are potentially useful because they take advantage of policy variation across countries. However, a challenge to causal inference is that there might be unobserved variables that are correlated with individual or national indicators and that affect child outcomes. Our study aims to address this challenge by using multiple waves of data and including country and year fixed effects. Nevertheless, we recognize that with only two waves of data, our power to detect effects will necessarily be limited, and therefore we plan to include further waves of data (as those become available) in future work.

Our approach draws on two prior literatures. First, we build on studies such as Hampden-Thompson and Johnston (2006) which have demonstrated that some individual-level variables, including both school (e.g., curriculum and teacher qualifications) and non-school (e.g., students' socioeconomic and immigrant status) factors, are key predictors of children's educational achievement. Including such individual-level controls is essential, particularly given the differences in school and non-school characteristics of children across countries. Second, to inform our analysis of the role of policies, we draw on two cross-national studies that have examined the effects of parental leave policies, and other child and family policies, on infant health (and other outcomes). These exemplary studies by Ruhm (2000) and Tanaka (2005) use multiple waves of data across countries over time and include country and year fixed effects, as well as controls for other relevant social expenditures. The inclusion of the country and year fixed effects is key, since it means that the analyses provide estimates of the effects of changes in policies within countries over time. In the case of parental leave, these studies indicate the effect on infant health of a country extending its period of paid parental leave, holding constant fixed characteristics of the country as well as secular trends in infant health across countries over time. We utilize a similar approach here, although as noted we are limited in that we have only two waves of data at present.

Thus, our study expands on the prior literature on the effects of public preschool expenditures on student achievement in two ways. First, utilizing a similar methodology to Ruhm (2000) and Tanaka (2005) in their work on parental leave policies, our study provides the first cross-national evidence as to whether public preschool expenditures are associated with higher math and science scores for 4^{th} graders, holding constant child, family, and school characteristics, other relevant social expenditures, and country and year effects. Using the same methodology, we also provide evidence on whether preschool expenditures matter more for children from disadvantaged backgrounds.

DATA

We use data from two waves of TIMSS, 1995 and 2003. TIMSS collects educational achievement data, as well as extensive background information regarding child, family, teacher, and school factors related to the learning and teaching of math and science, for children who are primarily in the 4^{th} grade and 8^{th} grade. This study uses data on 4^{th} graders, so that we can estimate the effects of preschool experiences as close to school entry as possible. We focus our analysis on countries who are present in both waves of the TIMSS data and for whom we have complete data on public expenditures, our main independent variable of interest. Our sample includes all seven countries that meet both conditions: Australia, Japan, Netherlands, New Zealand, Norway, U.K., and U.S.

Our outcome variables are the math and science test scores of children in the 4^{th} grade in TIMSS 1995 and 2003. The test scores are comparable across countries in each wave, but their distributions vary across the two waves. For example, the math scores in the 1995 wave have a mean of 542 with a standard deviation of 91, while in the 2003 wave, the mean is 512

with a standard deviation of 81. To make them comparable between waves, the test scores are standardized in each wave to have a mean of 100 and a standard deviation of 10.

Because the TIMSS survey is administered at school rather than at the household, it lacks some important socio-demographic information about the child's parents and family background. For example, the TIMSS 1995 and 2003 for 4th graders have no information about parents' education[1] and employment or family structure and income. However, the TIMMS does include some information gathered from the child about his or her home environment. In this study, we use information that is likely to reflect the socioeconomic status of the family and the family's attitudes towards and support for education, including variables for the immigration status of parents, whether the test language is always spoken at home, the number of books in the home, and controls for whether the child has a calculator, computer, study desk, or dictionary at home.

We use several strategies to keep observations with missing values in the analysis. For categorical variables, a category of missing is created to flag observations with missing values. For continuous variables, the means of the non-missing observations are used to impute the missing values, and a dummy variable is created to note whether the values of observations are missing or imputed. In both cases, the categories that indicate missing observations are always included in the regression models (but for the sake of simplicity, we do not report the coefficients on those missing variable dummies). The percentage of cases missing data on any item is shown in Table 1.

Our final analysis sample includes 62,294 observations, with 28,437 from TIMSS 1995 and 33,857 from 2003. As shown in Table 1, the distribution of children participating in TIMMS from our seven sample countries is fairly constant across the two waves, although Australia dropped from being 23% of the sample in 1995 to 13% in 2003. On average, children in the sample were about 10 years old and evenly distributed by gender. About 16% of the children in 1995 and 22% in 2003 had parents born in a foreign country, and about 10% of the children did not always speak the test language at home. Most of the children spent some time doing jobs at home and reading books for enjoyment. The majority of children had more than 25 books at home, and had a calculator, computer, study desk, and dictionary at home.

TIMMS also includes extensive data about teacher and school characteristics that are likely to matter for students' achievement in math and science. Descriptive statistics for these variables are also shown in Table 1. .

Our data on public expenditures on preschool and primary school education are extracted from the OECD Online Database (OECD, 2005a). We convert the data on total public expenditures on preschool and primary school to expenditures per child by dividing the total expenditures on each item by the number of children in the relevant age group. Thus, our measures capture how much the government spends per child in that age group, not how much the government spends per enrolled child. This is the correct measure since we want to gauge both how many children the public expenditures reach and how generous the expenditures are per enrolled child. (This distinction is of little importance for primary school, but is important for preschool since the share of children served by public programs is not 100% and varies considerably across countries).

Data on other public social expenditures per capita, including spending on family cash benefits, health, and other social spending (this consists of programs such as old age

[1]The TIMSS 1995 and 2003 data on 8th graders do include information on parental education.

benefits, survivors, incapacity-related benefits, employment, unemployment, and housing) are from OECD Health Data 2005 (OECD, 2005b). These figures are provided by OECD on a per capita basis and we use them in this form (it would not be correct to standardize on a per child basis as these expenditures are intended to reach adults as well as children). All the expenditure figures are exchanged into 2000 U.S. dollars adjusted by purchasing power parity (PPP) so that they are comparable across countries and years.

We then assign to each child the average value of the expenditure variables in his or her country during his or her preschool years, and during his or her primary school years. For children in the 4th grade in 1995, we define their preschool years as 1985–1991, and their primary school years as 1991–1995. For children in the 4th grade in 2003, we define their preschool years as 1993–1999, and their primary school years as 1999–2003.

Table 2 shows that Norway had the highest expenditures per child on preschool programs in both waves, while Japan and Australia ranked as the lowest spending countries. The U.S. ranked third among the seven countries in both years with the second highest increase in the level of spending from 1995 to 2003. Norway raised its preschool expenditures dramatically during this period while Australia, in contrast, reduced its spending. All countries spent substantially more per child on primary school expenditures than on preschool expenditures. Norway again was the highest spender on primary school expenditures per child, followed by the U.S. Norway also had the highest expenditure per capita on family cash benefits, health, and other social programs during both waves, while the U.S. mostly stood in the middle among these countries.

METHODS

We would like to know whether higher public preschool expenditures are associated with better student achievement, holding constant other factors that vary across countries, as well as across students. Ideally, we would like to control for observed country differences and also unobserved country-level factors that may be correlated both with higher spending and with better outcomes.

To address the problem of unobserved heterogeneity across countries, this study uses ordinary least squares (OLS) regression analysis with country and year fixed effects, as well as controls for school and non-school factors. The inclusion of country and year fixed effects is important, as it means that our estimates of the effect of preschool expenditures reflect the effect of changes in those expenditures within countries over time. Since other expenditures, such as primary education and social expenditures may also affect the educational achievement of children in the 4th grade, our analysis also controls for public expenditures on primary education and other social programs.

The basic model used in this study is:

$$S_{ict}=\beta_0+\gamma_c+\gamma_t+\beta_i X_{ict}+\beta_p E_{ct}+\varepsilon_{ict}$$

where S_{ict} represents the test scores of individual child i from country c at time t; γ_c is the country fixed effect; γ_t stands for the year fixed effect; X_{ict} represents a vector of child, family, teacher, and school characteristics related to individual child i in country c at time t; E_{ct} indicates public expenditures, including expenditures on preschools, primary schools, and other social programs, in country c at time t; and ε is a random error term.

Our estimation approach involves a series of increasingly controlled models, so that we can see first the raw differences in school achievement across countries and then how those

differences change as controls for key sets of predictor variables are added. Our first model predicts children's math and science scores in the 4th grade as a function only of country fixed effects and a control for the earlier wave of data, 1995. We include country dummies for Australia, Japan, Netherlands, New Zealand, Norway, and U.K., so our base case is a 4th grader from the U.S. in 2003. Model 2 adds controls for child age, gender, and family size, controls for whether the child had a parent who is an immigrant and whether the test language was always spoken at home, and controls for the child doing jobs and reading books at home, as well as home resources such as having fewer than 25 books in the home and not having a calculator, computer, study desk, or dictionary. Model 3 adds teacher and school characteristics, including the teacher's age, gender, education, years of teachers, class size, urban location, percent of students absent, and percent of students from disadvantaged families. Then, we estimate five additional models exploring the role of preschool and other policies. In Model 4, we add a control for public expenditures on preschool per child as well as primary education expenditures per child. These controls capture the main variable of interest in this study – public preschool expenditures – as well as primary school expenditures which are important in their own right and may also be correlated with preschool expenditures. As a robustness check, in Model 5, we add detailed controls for three other types of social expenditures (family cash benefits, health, and other social programs) that occurred during the child's preschool years, while in Model 6 we add detailed controls for the amount of expenditures on these three other categories of programs during the child's primary school years to date. As a further robustness check, Models 7 and 8 control instead for measures of total other expenditures during the preschool years and primary school years.

To examine whether disadvantaged children benefit more from preschool expenditures than their peers, we add interactions between disadvantaged background factors and public expenditures to the models. We use two sets of background factors to measure possible disadvantage. The first set includes measures of low resources including whether the child did not have a calculator, computer, study desk, or dictionary at home. The second set includes a variable for whether the test language was not always spoken at home.. Both sets of factors have been found to have strong effects on student test scores across countries (see for example Esping-Anderson, 2005). We do not use the immigrant status of the family as an indicator of disadvantage, because the links between immigrant status and school achievement are likely to vary a good deal depending on factors such as the family's country of origin, the parents' education and employment status, and the policies of the receiving country (see for example Schnepf, 2004).

RESULTS

The results for children's math scores are shown in Table 3. We begin with a model that simply estimates raw differences across countries, as compared to the base case of a 4th grader in the U.S. in 2003. The results indicate that 4th graders from Japan and the Netherlands out-score 4th graders from the U.S. by about 6.7 and 4.5 points respectively. Since the standard deviation of the test score outcome variable is 10, these coefficients translate into differences of .67 and .45 of a standard deviation respectively. Fourth graders in the other four countries have mean scores ranging from .07 standard deviations above the U.S. mean to .58 standard deviations below the U.S. mean.

We next add controls for child age, gender, and family size, parent immigrant status and language at home, and other child and home characteristics (Model 2). These controls affect math scores in the expected direction, with children of immigrants, children who do not always speak the test language at home, and children with fewer books or lacking other resources in the home scoring more poorly in math, but adding them to the model does not

substantially alter the country positions. In Model 2, 4th graders from the Netherlands, for instance, have an advantage of .36 of a standard deviation, as compared to .45 in Model 1. The addition of teacher and school characteristics in Model 3 has a somewhat larger effect on the country coefficients. The Netherlands advantage, for instance, is reduced to 0.26 of a standard deviation. Like the child and family characteristics, the teacher and school characteristics work as expected. For instance, children have higher math scores when they have teachers who have more experience and are in smaller classes, and when they are in schools that have lower absentee rates and lower percentages of disadvantaged students.

Model 4 adds the control for public preschool expenditures per preschool age child. The coefficient is small but statistically significant, indicating that a $100 per child increase in public preschool expenditures is associated with a gain of .07 of a standard deviation in 4th graders' math scores. The model also controls for public primary school expenditures per school age child, but the coefficient on this variable is negative, indicating that when countries increase their primary school expenditures by $100 per child, math scores fall by an average of .03 of a standard deviation. This latter result is somewhat puzzling but is not inconsistent with the prior literature which finds that higher school expenditures are not always associated with improved school achievement (Hanushek, 2006). One possible reason is that such expenditures may be endogenous (if school spending goes up when achievement is lagging or when more special needs students are enrolled).

Adding the controls for preschool and primary school expenditures in Model 4 does alter some of the country coefficients. Most dramatically, the coefficient for the Netherlands switches sign and is now .51 of a standard deviation below the U.S. average, suggesting that preschool expenditures play a role in explaining the Netherlands' superior position in the prior models. New Zealand and U.K. also have more negative means relative to the U.S. than they did in prior models, suggesting that that for them as well, higher preschool expenditures confer advantages relative to the U.S.

As a robustness check, we estimate four additional models, adding detailed controls for other social expenditures during the preschool years (Model 5), detailed controls for other social expenditures during both the preschool and primary school years (Model 6), controls for total other social expenditures during the preschool years (Model 7), and controls for total other expenditures during the preschool and primary school years (Model 8). These expenditure variables are fairly highly correlated and it may not be appropriate to control for all of them in the same model. However, if these controls are omitted, our estimates of the effects of preschool expenditures may be biased. Therefore, we do not emphasize results from one model but rather consider the range of preschool coefficients across models. In the models with detailed controls for other expenditures, the effect of a $100 per child increase in preschool expenditures increases to .11 (Model 6) and .13 (Model 5) of a standard deviation. When we instead add controls for total other expenditures during the preschool years or preschool and primary school years, the effect of a $100 per child increase in expenditures falls again, to .08 (Model 7) and .09 (Model 8) of a standard deviation.[2]

Selected results for children's science test scores, focusing on the effect of public preschool expenditures, our main independent variable of interest, are shown in Table 4 (complete results are available on request). As with math scores, we find that public preschool expenditures have small but statistically significant effects on 4th graders' science scores.

[2]As a further robustness check, we re-estimated our models dropping Norway, which might be viewed as an outlier given its high level of preschool expenditures. In results not shown but available upon request, the coefficients on the preschool expenditure variable were basically unchanged. We also re-estimated the models including only the four Anglo-American countries (U.S., U.K., Australia, and New Zealand) as they arguably are a more homogeneous group. In those results (not shown but available upon request), the coefficients on the preschool expenditure variable were larger than for the full seven country sample (ranging from .008 to .032)

These effects are considerably smaller than they are for math scores, ranging from a coefficient of .003 (Model 4) to a coefficient of .007 (Model 5), implying that a $100 per child increase in expenditures would be associated with an increase of between .03 and .07 of a standard deviation in science test scores.[3]

We also conduct supplemental models to examine whether public preschool expenditures reduce the risk of low-level proficiency. Low-level proficiency refers to students' performing at or below the low international benchmark (400 for both math and science scores), at the level of which students show some basic knowledge of math and science[4]. We find that higher preschool expenditures significantly reduce the likelihood that a child performs at the low level of proficiency, although the magnitude of the effect is small (results not shown but available upon request).

We now turn to the question of whether the effects of preschool expenditures are larger for more disadvantaged children. We consider several measures of low resources in the home: not having a calculator; not having a computer; not having a study desk; and not having a dictionary. These measures are highly correlated (Pearson correlation coefficients larger than 0.66) and factor analysis indicates that they load onto one factor. In the interests of space, we show results for only one measure, not having a calculator (results using the other three measures are similar and are available upon request).

We begin with our simplest preschool expenditure model from Tables 3 and 4 (Model 4) and test for differential effects of preschool expenditures for disadvantaged children by adding interaction terms to the model.[5] Thus, when testing for larger (or smaller) effects for children who lack a calculator in the home, we include (in addition to the main effect for lacking a calculator and the control for public preschool expenditures per child) an interaction term for lacking a calculator and the level of public preschool expenditures per child. The coefficient on the interaction term tells us whether the effect of public preschool expenditures is significantly different for children who lack a calculator in the home than for other children.

The results for math scores are shown in first three columns of Table 5, and the results for science scores are shown in the next three columns. As can be seen in Table 5, we find that not having a calculator in the home is associated with significantly lower math and science scores. Moreover, the interaction between not having a calculator and preschool expenditures is positive and significant in both models, indicating that preschool expenditures are more beneficial for children who lack this resource in the home. (As noted above, results for the other indicators of low resources in the home were similar).

Finally, we consider whether preschool expenditures are more beneficial for children who do not speak the test language at home, as this may also disadvantage them in math and science. Across both math and science, we find that children who do not speak the test language at home score significantly more poorly, and the interaction between preschool expenditures and not speaking the test language at home is positive and significant in the science model, although not in the math model (Table 5). These results provide some evidence that preschool expenditures are more beneficial for children who do not always speak the test language at home, at least in science.

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[3]Again, these results (not shown but available upon request) were robust to dropping Norway, or estimating the models just for the four Anglo-American countries.

[4]For details about the international benchmarks of math and science achievement, see Mullis et al. (2004) and Martin et al. (2004).

[5]We also estimated interaction models based on Models 5–8, where we interacted the group indicator (for example, child of immigrant) with each of the expenditure variables. In results not shown but available on request, the effects of the interaction between the group indicators and public preschool expenditures were basically the same as in the results presented in Table 5.

CONCLUSIONS

This study examined the effects of public preschool expenditures on the math and science scores of 4th graders, holding constant child, family, and school characteristics, other relevant social expenditures, and country and year effects, using data from the TIMSS 1995 and 2003 waves for children from seven OECD countries -- Australia, Japan, Netherlands, New Zealand, Norway, U.K., and U.S. We also explored whether preschool expenditures matter more for children who may be at risk of poor school achievement, as indexed by having low levels of resources in the home or not always speaking the test language at home.

Our results indicate that there are small but significant positive effects of public preschool expenditures on the math and science scores of 4th graders. Across our sample countries, public preschool expenditures per child range from a low of $156 per child in Japan in 1995 to a high of $3415 per child in Norway in 2003; the median increase from 1995 to 2003 was $245 per child (in New Zealand). We find that an increase in preschool expenditures of $100 per child would lift children's math scores by .07 to .13 of a standard deviation, and would raise their sciences scores by .03 to .07 of a standard deviation. These estimates are somewhat sensitive to how we control for other social expenditures but in each model remain positive and statistically significant. In supplemental models, we find that preschool expenditures also reduce the risk of children scoring at a low level of proficiency, in both science and math.

We find evidence that children from low-resource homes may gain more from increased public preschool expenditures than other children and that children who do not always speak the test language at home may gain more from preschool expenditures, at least in science. Thus, this study provides evidence that increasing public preschool expenditures would raise children's math and science achievement and that such expenditures would help close gaps in achievement between less and more advantaged students.

A key concern in this study is controlling for unobserved heterogeneity across countries that may be correlated with both public spending and student achievement. We attempt to address this heterogeneity by using multiple waves of data and including country fixed effects as well as year effects, but as noted earlier, our analyses are limited in that we have only two waves of data per country. We can not be certain that we have controlled for all the factors that vary across countries and that may matter for student achievement as well as public spending. The TIMSS data on 4th graders contain few controls for key family background variables such as parental education or for the quality of preschool or school programs that children attend. Moreover, we do not control for private expenditures on preschool, or for differences in the types of programs funded by public expenditures.

In spite of these shortcomings, it is striking how consistent our results are across models in pointing to a small but significant positive association between public preschool expenditures and higher student math and science scores in the 4th grade. These results suggest that public preschool expenditures may play a role in raising children's math and science achievement. The exact magnitude of these effects, how they come about, and whether and how they vary across different groups of children are all excellent topics for further research. In particular, future research should consider the extent to which preschool programs help children of immigrants close achievement gaps. The answer to this question is likely to vary a good deal by country. In some countries, children of immigrants may be less likely to attend such programs than their native peers. Furthermore, as discussed earlier, the links between being a child of immigrant and school achievement may vary considerably

across countries, depending on many factors such as their country of origin, parents' education and employment, family income and assets, and policies of the receiving country.

Our results do have some implications for policy. As indicated earlier, compared to the funding allocated to primary school education, the overall public investment in ECEC is relatively low in most countries. Data in Table 2 show that in 2003 the average expenditure on preschool programs per child as a percentage of that on primary school programs ranged from 2.8% in Australia to 24.4% in the Netherlands, with 16.5% in the U.S. in the middle. If this percentage increased to 50% in all countries studied, preschool expenditures would be raised by between $1,511 (in U.K.) and $3,143 (in Australia). Based on the findings in this study, such increases would lift children's average math scores by 1.06 to 4.09 of a standard deviation and their average science scores by .45 to 2.20 of a standard deviation. The increases are likely to be even larger for the most disadvantaged children. Therefore, our results support the importance of policy makers increasing preschool expenditures to help children, especially those from low-resource families, boost their school achievement and avoid being left behind.

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Table 1

Descriptive Statistics of Child, Family, Teacher, and School Characteristics

Variables	1995 (N = 28,437)	2003 (N = 33,857)
Participated Countries		
Australia	0.23 (0.42)	0.13 (0.33)
Japan	0.15 (0.36)	0.13 (0.34)
Netherlands	0.09 (0.28)	0.09 (0.28)
New Zealand	0.09 (0.28)	0.13 (0.33)
Norway	0.08 (0.27)	0.13 (0.33)
U.K.	0.11 (0.31)	0.11 (0.31)
U.S.	0.26 (0.44)	0.29 (0.45)
Child and Family Characteristics		
Child's age		
Months (imputed)	122.20 (5.47)	121.58 (5.39)
Missing	0.02 (0.13)	0.02 (0.14)
Girl		
Yes	0.50 (0.50)	0.50 (0.50)
No	0.50 (0.50)	0.50 (0.50)
Missing	0.00 (0.06)	0.00 (0.02)
Number of family members		
Members (imputed)	4.89 (1.52)	4.76 (1.34)
Missing	0.19 (0.39)	0.04 (0.20)
Child of immigrants		
Yes	0.16 (0.36)	0.22 (0.42)
No	0.63 (0.48)	0.69 (0.46)
Missing	0.22 (0.41)	0.09 (0.28)
Always speaking test language at home		
Yes	0.68 (0.47)	0.89 (0.31)
No	0.10 (0.31)	0.09 (0.29)
Missing	0.22 (0.41)	0.02 (0.14)
Child does jobs at home		
No time	0.15 (0.35)	0.16 (0.37)
Less 1 hour	0.48 (0.50)	0.45 (0.50)
1–2 hours	0.22 (0.41)	0.20 (0.40)
More than 2 hrs	0.10 (0.30)	0.14 (0.35)
Missing	0.06 (0.24)	0.05 (0.21)
Child reads books for enjoyment		
No time	0.19 (0.39)	0.20 (0.40)
Less 1 hour	0.43 (0.50)	0.42 (0.49)
1–2 hours	0.21 (0.41)	0.20 (0.40)
More than 2 hrs	0.10 (0.30)	0.14 (0.35)
Missing	0.06 (0.24)	0.05 (0.21)

Variables	1995 (N = 28,437)	2003 (N = 33,857)
Number of books at home		
0–25 books	0.14 (0.35)	0.29 (0.46)
More than 25 books	0.66 (0.47)	0.68 (0.47)
Missing	0.19 (0.39)	0.02 (0.15)
Have a calculator at home		
Yes	0.74 (0.44)	0.90 (0.30)
No	0.08 (0.28)	0.06 (0.24)
Missing	0.18 (0.38)	0.04 (0.19)
Have a computer at home		
Yes	0.52 (0.50)	0.86 (0.35)
No	0.30 (0.46)	0.11 (0.31)
Missing	0.18 (0.38)	0.03 (0.17)
Have a study desk at home		
Yes	0.71 (0.45)	0.82 (0.39)
No	0.11 (0.31)	0.16 (0.36)
Missing	0.18 (0.38)	0.03 (0.16)
Have a dictionary at home		
Yes	0.71 (0.45)	0.84 (0.37)
No	0.11 (0.31)	0.14 (0.34)
Missing	0.18 (0.38)	0.02 (0.15)
Teacher and School Characteristics		
Teacher's age		
Young (<30)	0.15 (0.36)	0.19 (0.39)
Middle age (30–49)	0.60 (0.49)	0.49 (0.50)
Old age (50+)	0.15 (0.36)	0.24 (0.43)
Missing	0.10 (0.30)	0.08 (0.28)
Female teacher		
Yes	0.63 (0.48)	0.70 (0.46)
No	0.27 (0.44)	0.22 (0.41)
Missing	0.10 (0.29)	0.08 (0.27)
Teacher's education		
Secondary & lower	0.33 (0.47)	0.22 (0.41)
BA/equivalent	0.29 (0.45)	0.50 (0.50)
MA/PHD	0.12 (0.32)	0.19 (0.39)
Missing	0.26 (0.44)	0.09 (0.28)
Teacher's years of teaching		
Years (imputed)	15.64 (8.54)	14.82 (10.12)
Missing	0.10 (0.31)	0.10 (0.30)
Teacher's class size		
Number of children (imputed)	26.97 (6.23)	26.01 (5.78)
Missing	0.16 (0.37)	0.29 (0.45)
Rural area of school		

Variables	1995 (N = 28,437)	2003 (N = 33,857)
Yes	0.19 (0.39)	0.23 (0.42)
No	0.70 (0.46)	0.67 (0.47)
Missing	0.11 (0.32)	0.10 (0.30)
Percentage of students absent at school		
Less than 5%	0.71 (0.45)	0.74 (0.44)
More than 5%	0.15 (0.36)	0.18 (0.38)
Missing	0.13 (0.34)	0.08 (0.28)
Percentage of students from disadvantaged families at school		
0–10%	0.17 (0.37)	0.31 (0.46)
11–50%	0.15 (0.35)	0.28 (0.45)
>50%	0.05 (0.23)	0.18 (0.39)
Missing	0.63 (0.48)	0.23 (0.42)

Note. Means with standard deviations in parentheses.

Table 2

Public Education and Social Expenditures by Country and Year

Public Education and Social Expenditures during Preschool Years (PPP 2000 U.S. Dollars)												
	Preschool Expenditures (per Child)			Public Social Expenditures (per Capita)								
				Family Cash Benefits			Health			Others Social Expenditures		
	Wave 1995	Wave 2003	Differences	Wave 1995	Wave 2003	Differences	Wave 1995	Wave 2003	Differences	Wave 1995	Wave 2003	Differences
Australia	207	189	−18	215	563	348	813	1252	439	1094	2033	939
Japan	156	351	195	65	104	39	761	1256	495	1019	1854	835
Netherlands	1249	1481	232	280	294	14	841	1308	467	3175	4045	870
New Zealand	294	539	245	337	407	70	717	1009	292	1677	2029	352
Norway	2047	3415	1368	447	904	457	1068	1752	684	1398	3894	2496
U.K.	525	856	331	313	480	167	740	1193	453	1942	3055	1113
U.S.	914	1398	484	101	155	54	921	1701	780	1692	2436	744

Public Education and Social Expenditures during Primary School Years (PPP 2000 U.S. Dollars)												
	Primary school Expenditures (per Child)			Public Social Expenditures (per Capita)								
				Family Cash Benefits			Health			Others Social Expenditures		
	Wave 1995	Wave 2003	Differences	Wave 1995	Wave 2003	Differences	Wave 1995	Wave 2003	Differences	Wave 1995	Wave 2003	Differences
Australia	4519	6663	2144	412	743	331	1030	1634	604	1699	2418	719
Japan	4800	6828	2028	86	141	55	1074	1561	487	1501	2463	962
Netherlands	4483	6060	1577	298	314	16	1215	1516	301	4009	4180	171
New Zealand	3498	5231	1733	339	469	130	894	1244	350	1975	2177	202
Norway	8831	14305	5474	752	1120	368	1451	2347	896	3440	4850	1410
U.K.	4959	4734	−225	418	554	136	1040	1505	465	2712	3462	750
U.S.	6673	8487	1814	154	132	−22	1447	2022	575	2224	2732	508

Table 3

OLS Regression Results for Math Scores

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Wave of Data (wave 2003 omitted)								
Wave 1995	−0.588*** (0.076)	−0.572*** (0.079)	−0.828*** (0.096)	−3.675*** (0.143)	−5.711*** (0.366)	−3.752*** (0.791)	−4.923*** (0.249)	−5.033*** (0.249)
Participating Countries (the U.S. omitted)								
Australia	0.737*** (0.116)	−0.211** (0.107)	−0.792*** (0.126)	−0.013 (0.219)	−1.658*** (0.384)	5.476*** (0.830)	1.046*** (0.279)	1.821*** (0.306)
Japan	6.913*** (0.123)	5.815*** (0.140)	3.929*** (0.173)	5.905*** (0.266)	8.430*** (0.331)	10.947*** (0.472)	6.205*** (0.270)	6.974*** (0.298)
Netherlands	4.495*** (0.146)	3.597*** (0.134)	2.623*** (0.168)	−5.134*** (0.277)	−0.140 (0.537)	11.073*** (1.109)	−3.143*** (0.427)	−4.005*** (0.449)
New Zealand	−2.406*** (0.135)	−2.639*** (0.124)	−3.307*** (0.152)	−7.161*** (0.230)	−8.805*** (0.483)	0.000 (0.000)	−5.986*** (0.300)	−4.502*** (0.384)
Norway	−5.760*** (0.136)	−6.020*** (0.131)	−6.553*** (0.164)	−6.002*** (0.368)	−18.496*** (1.100)	0.000 (0.000)	−7.456*** (0.438)	−12.705*** (0.957)
U.K.	0.291** (0.135)	−0.822*** (0.124)	−0.934*** (0.138)	−5.414*** (0.203)	−4.851*** (0.431)	5.690*** (0.465)	−3.710*** (0.344)	−3.947*** (0.346)
Child and Family Characteristics								
Child's age (months)		2.039*** (0.125)	1.948*** (0.123)	1.671*** (0.122)	1.631*** (0.122)	1.633*** (0.122)	1.644*** (0.123)	1.637*** (0.123)
Child's age (squared)		−0.008*** (0.001)	−0.008*** (0.000)	−0.007*** (0.000)	−0.006*** (0.000)	−0.006*** (0.000)	−0.006*** (0.000)	−0.006*** (0.000)
Girl		−1.122*** (0.069)	−1.087*** (0.068)	−1.089*** (0.067)	−1.088*** (0.067)	−1.089*** (0.067)	−1.087*** (0.067)	−1.086*** (0.067)
Number of members		−0.523*** (0.024)	−0.477*** (0.024)	−0.459*** (0.024)	−0.453*** (0.024)	−0.452*** (0.024)	−0.458*** (0.024)	−0.458*** (0.024)
Child of immigrants		−0.157* (0.095)	−0.125 (0.095)	−0.081 (0.094)	−0.115 (0.094)	−0.131 (0.094)	−0.093 (0.094)	−0.074 (0.094)
Not always speaking test language at home		−3.169*** (0.125)	−2.826*** (0.124)	−2.814*** (0.123)	−2.847*** (0.122)	−2.840*** (0.122)	−2.813*** (0.123)	−2.838*** (0.123)
Child does jobs at home (no time omitted)								
Less 1 hour		1.494*** (0.101)	1.449*** (0.100)	1.456*** (0.099)	1.455*** (0.099)	1.452*** (0.099)	1.452*** (0.099)	1.456*** (0.099)
1–2 hours		0.349*** (0.117)	0.360*** (0.115)	0.356*** (0.114)	0.365*** (0.114)	0.363*** (0.114)	0.348*** (0.114)	0.354*** (0.114)
More than 2 hrs		−2.524*** (0.135)	−2.360*** (0.133)	−2.317*** (0.131)	−2.309*** (0.131)	−2.309*** (0.131)	−2.322*** (0.131)	−2.321*** (0.131)
Child reads books for enjoyment (no time omitted)								
Less 1 hour		1.781*** (0.095)	1.717*** (0.093)	1.806*** (0.092)	1.766*** (0.092)	1.764*** (0.092)	1.798*** (0.092)	1.791*** (0.092)
1–2 hours		2.941*** (0.111)	2.877*** (0.109)	2.987*** (0.108)	2.940*** (0.108)	2.937*** (0.108)	2.982*** (0.108)	2.974*** (0.108)
More than 2 hrs		2.334*** (0.129)	2.340*** (0.127)	2.478*** (0.126)	2.424*** (0.125)	2.423*** (0.125)	2.471*** (0.126)	2.457*** (0.126)
Less than 25 books at home		−4.015*** (0.088)	−3.650*** (0.087)	−3.523*** (0.087)	−3.509*** (0.086)	−3.504*** (0.086)	−3.524*** (0.087)	−3.528*** (0.087)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
No calculator at home		−3.590*** (0.138)	−3.349*** (0.136)	−3.511*** (0.135)	−3.552*** (0.135)	−3.555*** (0.135)	−3.537*** (0.135)	−3.530*** (0.135)
No computer at home		−1.610*** (0.093)	−1.459*** (0.092)	−1.664*** (0.092)	−1.521*** (0.093)	−1.512*** (0.093)	−1.623*** (0.092)	−1.611*** (0.092)
No study desk at home		−1.659*** (0.106)	−1.416*** (0.105)	−1.305*** (0.104)	−1.340*** (0.103)	−1.347*** (0.104)	−1.296*** (0.103)	−1.297*** (0.103)
No dictionary at home		−2.106*** (0.109)	−1.956*** (0.108)	−2.102*** (0.108)	−2.091*** (0.108)	−2.098*** (0.108)	−2.137*** (0.108)	−2.111*** (0.108)
Teacher and School Characteristics								
Teacher's age (younger than 30 omitted)								
Middle age (30–49)			0.033 (0.110)	0.111 (0.109)	0.060 (0.109)	0.060 (0.109)	0.101 (0.109)	0.089 (0.109)
Older age (50+)			−0.288* (0.166)	−0.245 (0.164)	−0.290* (0.164)	−0.295* (0.164)	−0.262 (0.164)	−0.265 (0.164)
Male teacher			0.055 (0.082)	−0.027 (0.081)	−0.065 (0.081)	−0.058 (0.081)	−0.020 (0.081)	−0.044 (0.081)
Teacher's education (secondary school and lower omitted)								
BA/equivalent			−0.104 (0.104)	−0.107 (0.103)	−0.114 (0.103)	−0.090 (0.104)	−0.084 (0.103)	−0.152 (0.103)
MA/PHD			0.426*** (0.134)	0.382*** (0.133)	0.275** (0.133)	0.286** (0.133)	0.381*** (0.133)	0.319** (0.133)
Years of teaching			0.026*** (0.005)	0.032*** (0.005)	0.034*** (0.005)	0.034*** (0.005)	0.033*** (0.005)	0.032*** (0.005)
Teacher's class size			−0.050*** (0.006)	−0.045*** (0.006)	−0.043*** (0.006)	−0.043*** (0.006)	−0.041*** (0.006)	−0.042*** (0.006)
School in urban area			0.265*** (0.087)	0.392*** (0.086)	0.515*** (0.087)	0.518*** (0.087)	0.382*** (0.086)	0.422*** (0.086)
More than 5% of students absent at school			−1.403*** (0.098)	−1.253*** (0.097)	−1.242*** (0.097)	−1.241*** (0.097)	−1.247*** (0.097)	−1.248*** (0.097)
Percentage of students from disadvantaged families at school (0–10% omitted)								
11–50%			−2.050*** (0.102)	−1.870*** (0.101)	−2.024*** (0.102)	−2.033*** (0.102)	−1.873*** (0.101)	−1.905*** (0.101)
More than 50%			−4.272*** (0.132)	−4.599*** (0.131)	−4.839*** (0.134)	−4.848*** (0.134)	−4.600*** (0.131)	−4.651*** (0.132)
National Average Education and Social Expenditures (PPP U.S. Dollars)								
Preschool education expenditures				0.007*** (0.000)	0.013*** (0.001)	0.011*** (0.001)	0.008*** (0.000)	0.009*** (0.000)
Primary education expenditures				−0.003*** (0.000)	−0.003*** (0.000)	−0.003*** (0.000)	−0.003*** (0.000)	−0.003*** (0.000)
Expenditures on family cash benefits during preschool years					0.014*** (0.001)	0.008** (0.004)		
Expenditures on health during preschool years					−0.000 (0.001)	−0.010*** (0.002)		
Other social expenditures during preschool years					−0.006*** (0.000)	−0.003*** (0.001)		
Expenditures on family cash benefits during primary school years						−0.007* (0.004)		

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	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Expenditures on health during primary school years						0.021*** (0.001)		
Other social expenditures during primary school years						−0.005*** (0.001)		
Total social expenditures during preschool years							−0.001*** (0.000)	−0.003*** (0.000)
Total social expenditures during primary school years								0.002*** (0.000)
Constant	99.604*** (0.079)	−26.469*** (7.760)	−18.606** (7.659)	14.848* (7.638)	25.341*** (7.726)	14.792* (7.850)	18.246** (7.655)	15.298** (7.668)
Observations	62294	62294	62294	62294	62294	62294	62294	62294
R-squared	0.12	0.29	0.31	0.33	0.33	0.33	0.33	0.33

Note. 1. Standard errors in parentheses

* Marginally significant at 10%

** significant at 5%

*** significant at 1%.

Table 4

Selected OLS Regression Results for the Effects of Preschool Expenditures on Science Scores

	Model 4	Model 5	Model 6	Model 7	Model 8
Preschool education expenditures	0.003*** (0.000)	0.007*** (0.001)	0.006*** (0.001)	0.004*** (0.000)	0.005*** (0.000)
Primary education expenditures	−0.002*** (0.000)	−0.002*** (0.000)	−0.002*** (0.000)	−0.002*** (0.000)	−0.002***
Expenditures on family cash benefits during preschool years		0.011*** (0.001)	0.004 (0.004)		
Expenditures on health during preschool years		0.004*** (0.001)	−0.001 (0.002)		
Other social expenditures during preschool years		−0.006*** (0.000)	−0.003*** (0.001)		
Expenditures on family cash benefits during primary school years			0.001 (0.005)		
Expenditures on health during primary school years			0.015*** (0.001)		
Other social expenditures during primary school years			−0.007*** (0.001)		
Total social expenditures during preschool years				−0.002*** (0.000)	−0.002*** (0.000)
Total social expenditures during primary school years					0.001** (0.000)
Constant	23.972*** (7.940)	28.169*** (8.029)	21.732*** (8.157)	28.243*** (7.958)	27.241*** (7.973)
Observations	62294	62294	62294	62294	62294
R-squared	0.27	0.28	0.28	0.27	0.27

Note. 1. Standard errors in parentheses

Marginally significant at 10%

** significant at 5%

*** significant at 1%.

Table 5

OLS Regression Results for Math and Science Scores with Interactions between Disadvantaged Factors and Expenditures

		Math Scores			Science Scores		
			Preschool expenditures	Primary school expenditures		Preschool expenditures	Primary school expenditures
No calculator at home	Variable	−2.911*** (0.505)	0.007*** (0.000)	−0.003*** (0.000)	−1.387*** (0.524)	0.003*** (0.000)	−0.002*** (0.000)
	Interaction	-	0.002*** (0.000)	−0.000*** (0.000)	-	0.003*** (0.000)	−0.001*** (0.000)
Not always speaking test language at home	Variable	−1.908*** (0.433)	0.006*** (0.000)	−0.003*** (0.000)	−2.964*** (0.450)	0.002*** (0.000)	−0.002*** (0.000)
	Interaction	-	0.000 (0.000)	−0.000 (0.000)	-	0.001*** (0.000)	−0.000*** (0.000)

Note. 1. Standard errors in parentheses;

2. * Marginally significant at 10%; ** significant at 5%;

*** significant at 1%.