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Estimating the Expenditures Associated with Special Education: Evidence from Michigan*

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Abstract

Using a 13-year panel of school districts in Michigan, this paper estimates the average expenditures associated with different disability category labels. Increasing the number of students with disabilities by 1 student in the average school district is associated with an increase in expenditures between $1,998 for students with specific learning disabilities to more than a $23,000 increase in expenditures for students with low-incidence and severe disabilities. I find evidence that these expenditures may be driven by a higher identification of high-status disabilities and differential expenditure patterns in wealthier school districts.

1 Introduction

The population of students with disabilities (SWDs) in the U.S. has grown by more than 1.1 million students since the 2000-01 academic year, and school spending for special education has increased dramatically since this time (National Center for Education Statistics, 2023). As the federal government has not increased funding in the face of growing spending, school leaders must be cognizant of expenditures associated with legally-required special education programs and their funding sources (Kolbe, 2019).

*This research result used data structured and maintained by the MERI-Michigan Education Data Center (MEDC). MEDC data is modified for analysis purposes using rules governed by MEDC and are not identical to those data collected and maintained by the Michigan Department of Education (MDE), Michigan's Center for Educational Performance and Information (CEPI), or Michigan's Department of Lifelong Education, Advancement, and Potential (MiLEAP). Results, information and opinions solely represent the analysis, information and opinions of the author(s) and are not endorsed by, or reflect the views or positions of, grantors, MDE, CEPI, MiLEAP or any employee thereof.

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Substantial research has endeavored to quantify the expenditures associated with special education, and this research finds large and heterogeneous expenditures for students by disability. Using a survey of states across the U.S., Chambers et al. (2005) find that school districts spend \$13,047 more per SWD relative to a student without an identified disability. This premium ranges between \$8,748 for students with fewer specified services to \$29,596 for students with more services. The wide range of needs for SWDs and strong legal protections for these students under the Individual with Disabilities in Education Act (IDEA) necessitate these additional resources, and states use a variety of approaches to supplement funding for special education.

Among other approaches to provide funding for special education, 36 states have implemented weighted funding formulas. Under these policies, states provide additional funding on the bases of student counts by disability category and the intensity of services needed (Fischer & Duncombe, 2024). These formulas are intuitively appealing, and they scale flexibly to provide additional support for students with greater needs. Additional weights are often derived from cost function estimates in which researchers estimate the marginal change in spending associated with increases in different student populations (Gronberg et al., 2011).

While many researchers have applied cost functions to compute funding weights, no studies have used this approach to understand average expenditures allocated to different disability categories. This descriptive paper uses stochastic frontier models to determine how school district spending changes in response to increases in students in different disability categories. I estimate the additional expenditures associated with these characteristics using a panel of Michigan school districts between 2011-12 and 2024-25, and I convert estimates from stochastic frontier models into average dollar amount changes associated with different disabilities. Specifically, I ask what the average additional expenditure associated with a 1 student increase in each disability category is in Michigan, and I ask how expenditures for each disability category vary by the income level of school districts.

I find that Michigan school districts spend an average of \$8,493 more for the average SWD relative to a student without a disability. In addition, I find that expenditures vary dramatically by disability. School districts allocate the most funding to students with cognitive impairments, other health impairments, and Autism, and they allocate the fewest resources to students with specific learning disabilities on average. Comparing my estimates with prior studies of the costs of special education from Chambers et al. (2005) and the Autism Alliance of Michigan and Public Sector Consulting (2025), I find directional alignment across studies.

In addition to estimates of expenditures for each disability, I explore how estimated expenditures vary by school district-level income. Higher-income school districts spend more on average for students with emotional impairments, Autism, and other health impairments, and this is likely driven by the differential labeling of disabilities, prevalence of disabilities, and sorting of students into self-contained classrooms (Drake, 2020; Fish, 2019). In addition, I find that the composition of spending varies in high- and low-income school districts. This suggests that special education expenditures vary based on both disability classifications and characteristics of the school district potentially unrelated to the student. Policymakers working to improve equity in special education could consider adopting dynamic funding weights that account for both a student's disability status as well as the relative resources of the school district to provide services for that disability, or they could also consider expanding reimbursement systems to support special education programs.

2 Background

2.1 Costs of Special Education

Expenditures for special education support a wide array of services for students with disabilities. In this paper, I define expenditures for special education as the total amount that school districts choose to spend on special education programs and services. These include the salaries, benefits, supplies, and purchased services associated with special education teachers, speech pathologists, school psychologists, paraprofessionals, and other specialists.[1] Individualized education plans (IEPs) may require that students receive any of speech pathology services, psychological services including therapy, physical therapy, academic support and accommodations, and behavioral training, or other services to ensure that they have access to an appropriate education, and special education expenditure support these and other special education administration functions broadly (Parrish et al., 2015).

The exact dollar amount spent for a student with a disability depends on the range of services specified in the IEP, and IDEA requires that these services support SWDs to receive an "appropriate" public education ("Individuals with Disabilities Education Act", 2019). IEPs often specify that students receive a combination of services to support their needs, and a disability category does not define the services a student may receive. In this paper, I consider variation in spending by IDEA disability labels, and these legally defined categories comprise broad groupings of disabilities.[2] Disability labels are neither fixed nor

[1]Expenditures for special education are distinct from the theoretical "cost" of special education which would be comprised of the minimum expenditure necessary to achieve a specified educational outcome, and school districts have agency to set special education expenditure levels (Costrell et al., 2008; Gronberg et al., 2011).

[2]Many of the legal terms defined under IDEA related to disability labels are now outdated, and in many cases, research has identified new, more precise terms to describe disabilities. For example, cognitive impairments are now termed "intellectual and developmental disabilities" and emotional impairments are

inherent traits of students, and students with similar profiles could be identified with different disabilities depending on the experience and resources available.

To support these additional services, the federal government is expected to fund up to 40% of all special education expenditures in the U.S. through IDEA, although the program has never been funded to this level (Kolbe, 2019). Today, federal IDEA funding covers only about 15% of special education spending in the U.S., and this places the financial responsibility on states and local school districts to support special education (Kolbe, 2019; Kolbe et al., 2022).

In the absence of federal funding, state and local governments must use alternative policies to provide for special education services. State governments support special education expenditures through a variety of reimbursement programs, flat grants, and weighted funding formulas (Fischer & Duncombe, 2024). Reimbursement programs provide school districts with a portion of publicly reported special education expenditures as revenue in the following school year, and these programs vary from reimbursing 28.6% of special education expenditures in Michigan to 100% in Wyoming (Arsen et al., 2019).[3] Similarly, flat grants provide a fixed amount of funding per pupil or based on the total available resources for special education in the state.

Of the state-level approaches to special education finance, weighted funding formulas are the most common, and 36 states apply an additional funding weight for students with disabilities (Fischer & Duncombe, 2024).[4] A weighted funding formula establishes a baseline level of funding for every student, and students in specified categories such as economically disadvantaged students, English learners, and students with disabilities receive a function "multiplier" that increases their total funding (Ladd & Fiske, 2011). Weighted funding formulas are attractive as these differentiate funding aligned with student need, and these programs are intuitive to implement. These programs scale easily with student enrollment, and they can provide additive funding when students are identified with multiple disabilities. Nevertheless, states vary in how they implement these, and they may differentiate weights by disability category or intensity of services specified in the IEP (Augenblick, 2019, 2021; Danks et al., 2022). Further, states also vary regarding how they fund services for students with the greatest need (Fischer & Duncombe, 2024). For example, some states fund 100% of the expenditures for students with disabilities if expenditures pass a specific threshold.

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now termed "emotional and behavioral disorders." In this paper, I use the disability labels described under IDEA as these continue to be used in policy today.

[3]Arsen et al. (2019) find that Michigan has the lowest reimbursement rate among states using this approach to funding special education.

[4]Fischer and Duncombe (2024) find that 6 states use a reimbursement model, 6 states allocate resources proportionally across school districts, and 3 states use a hybrid approach to special education funding.

Given the need for states to calculate funding weights for special education, several national surveys have endeavored to quantify expenditures for students with disabilities. Students with disabilities almost universally require greater resources relative to students without disabilities (Chambers et al., 2002, 2005; Moore et al., 1988; Parrish et al., 2015). Chambers et al. (2005) estimate that the 1999-00 U.S. average per-pupil expenditure for a student with a disability was $13,047 more than a general education student in 2025 dollars. This average masks substantial variation by disability, and the authors of this study found that school districts spent $8,748 more for students with specific learning disabilities and $29,596 for students with multiple disabilities relative to students without any supplement services.

In addition to national surveys, numerous states have also worked to estimate funding weights for specific disabilities. Gray (2019) identifies 14 state-level cost studies in the U.S. that identify a range of additional weights for students with disabilities. These additional weights tend to be undifferentiated for students with disabilities or differentiated by high and low-intensity of services, although there are some states that target funding by disability. Beyond professional judgment estimates, several state-level cost studies have implemented cost function approaches to estimate funding weights for special education. These studies vary widely in how they incorporate students with disabilities in their models. For example, Gronberg et al. (2005) estimate a cost function in Texas, and they separate students with disabilities into high and low-intensity categories. They find that students with high-intensity disabilities cost school districts 83% more than students without disabilities.[5] Gronberg and colleagues find similar estimates in re-examinations of Texas in Gronberg et al. (2011) and Gronberg et al. (2015). These estimates are lower than those reported in Imazeki (2008) and Duncombe and Yinger (2005) who estimate additional expenditures in California and New York. These studies estimate an average expenditure premium between 100 and 200% for students with disabilities. To my knowledge, no cost function studies have incorporated proportions of students with individual disabilities in their models.

2.2 Context of Michigan School Finance

Michigan uses a reimbursement system to provide special education funding, and expenditures for students with disabilities are reimbursed post-hoc by the State according to a fixed percentage based on the 1998 Durant court case. Each year, school districts publicly report their total expenditures for special education, and they receive 28.6% of these back from the state in the following year (Cleary & Summers-Coty, 1999). As this is a fixed

[5] Gronberg et al. (2005) find a smaller 55% expenditure premium for students with less severe disabilities.

percentage, school districts are not incentivized to change spending in alignment with pre-existing funding amounts. For example, as school districts do not receive additional revenues for a student identified with a speech impairment versus a student identified with Autism, this system does not create financial incentives to identify students with specific disabilities (Ballis & Heath, 2021; Mahitivanichcha & Parrish, 2005).

In addition to district-level expenditures for special education, Michigan students with disabilities are also supported by Intermediate School Districts (ISDs). ISDs are county-level entities with dedicated special education funding, and school districts within ISDs may share resources to support students enrolled in special education programs. Given the additional expense of these programs, ISDs often operate dedicated centers where they provide special education services.

Conlin and Jalilevand (2015) describe this system of special education finance in Michigan, and they find substantial inequities across school districts regarding special education funding. ISDs are subject to different property tax maximums for special education, and as a result, they vary widely in their abilities to support local school districts to provide special education services (Arsen et al., 2019). As a result of these financial differences and the uneven distribution of students with disabilities across the state, Conlin and Jalilevand (2015) show that the financial support for students with disabilities is inconsistent across the state. In addition to this financial system, Michigan comprises a large, heterogeneous, and growing population of students with disabilities. Approximately 15.2% of Michigan's student population was identified with a disability during the 2021-22 academic year, and this parallels the national average (Hopkins et al., 2024). In addition, Hopkins et al. (2024) find that the population of students identified with disabilities has grown substantially faster in Michigan since the COVID-19 pandemic, and this growth was felt most strongly in the categories of SLI and Autism.[6] This dynamic environment provides an ideal context to explore trends in special education spending changes.

Two recent studies have used professional judgment approaches to compute disability weights for special education in Michigan. Augenblick (2019) and Augenblick (2021) recommend student-level weights based on each student's time spent in special education services, and they do not differentiate weights by disability. In contrast, the 2025 Michigan Special Education Blueprint recommends weights for special education by disability (see Table A1 for weights), and these weights are adapted to the Michigan context from research in Ohio. Given that the implied weights for students vary substantially under these recommendations, evidence of current expenditures for special education will provide valuable insight for

[6]The authors speculate that this is likely due to some perceived ease of access to resources as SLI takes less time to diagnose and some Autism services are reimbursed through health insurances.

policymakers regarding how to fund special education in the Michigan moving forward.

3 Data and Methods

3.1 Michigan Administrative Data

To understand the relationship between special education enrollment and school district-level spending, I use school district-level financial and student-level administrative data provided by the Michigan Education Research Institute-Michigan Education Data Center (MERI-MDEC) for all public and charter schools between the 2011-12 and 2024-25 academic years. Notably, I restrict my sample of Michigan school districts in three ways. First, I exclude all students in Michigan who are served in any capacity in dedicated special education centers. As these students often require substantially greater services relative to students served in local school districts, I do not consider expenditures for their services here. Second, I only keep school districts that offer education through high school. This removes some charter schools and very small school districts that only offer education through 8th grade, and these school districts may have lower expenditures due to the fact that they offer fewer educational programs. Finally, I also remove school districts with fewer than 500 students. Small enrollment in these districts artificially inflates per pupil expenditures due to fixed costs of staff and facilities, although I relax this restriction in some robustness checks.

Financial data are provided annually in Michigan State Aid Financial Status Reports (SAFSRs) and Michigan Department of Education Bulletin 1014 reports. SAFSRs contain school district-level total special education expenditures reported for state reimbursement and the total student full time equivalencies in each school district. Per pupil special education expenditures comprise all expenditures for salaries, benefits, educational supplies, and purchased services for special education programs and services, and these are divided by the total student full-time equivalencies (FTEs) in a school district to compute an average per pupil special education expenditure.[7]

In this paper, I define special education expenditures as all financial resources for any special education program or service. A special education "program" in Michigan describes a distinct educational environment with minimum teacher and paraprofessional staffing re-

[7] In Michigan, a student FTE is defined as a fractional value between 0 and 1 indicating the proportion of 1,098 minimum total instructional hours a student is scheduled to receive. This value is also separated for the amount of time spent in general education and special education services. For example, if a student were scheduled to receive special education programming for 1 hour per week and general education instruction for the rest of the week, this would equate to a 0.03 FTE in special education and 0.97 FTE in general education. This approach avoids double counting students if they appear in both a general education and special education program in the same school district.

quirements. Notably, students do not need to be physically in a special education classroom to receive special education programming, and they may receive programming through the support of a teacher or paraprofessional in a general education classroom or a self-contained special education classroom. In contrast, a special education "service" in Michigan describes an additional support to ensure that students with disabilities are educated in general education settings to the greatest extent possible. These include a range of services including speech pathology, psychological services, physical therapy, counseling services, and other services. Unlike special education programs, services do not have minimum staffing requirements, although they may have maximum allowable caseloads for specialists. Special education expenditures comprise all financial resources for the salaries and benefits of special educators and paraprofessionals as well as any supplies or purchased services associated with providing special education programs or services. These special education expenditures also include indirect costs and capital expenditures, and they exclude special education transportation expenditures. I use the log of per pupil special education expenditures as my primary dependent variable, and all dollar values are adjusted to constant 2025 dollars using the GDP State & Local price deflator following Burns and Guzman (2025) and Arsen et al. (2019).[8]

In addition to special education expenditures, I collect average teacher salaries in each school district from annual Michigan Department of Education Bulletin 1014 reports. These reports contain school district-level average teacher salaries, and this variable comprises a measure of input costs. As with per pupil special education expenditures, I incorporate the log of the inflation-adjusted average teacher salaries in my model. Beyond financial data, I use student-level data from the Michigan Education Research Institute (MERI)-Michigan Education Data Center (MEDC) between the 2011-12 and 2024-25 academic years. These comprise data unique at the student-year level that include each student's school and school district, gender, race or ethnicity, economically disadvantaged status, English learner status, and special education status. In Michigan, a student is designated as economically disadvantaged if they qualify for free or reduced price lunch, participate in SNAP or TANF programs, or are classified as homeless, a migrant student, or in foster care (MI School Data, 2026). In addition, for students with disabilities, the data include each student's primary disability, secondary disability, all special education programs and services that they received in each year, and the proportion of their educational time spent in special education programs. The data also contain students' standardized test scores in math and

[8] See Arsen et al. (2019) and Burns and Guzman (2025) for discussions of the differences between this inflation adjustment and the CPI inflation adjustment. These authors argue that the GDP S&L price deflator is more appropriate for education finance as school districts operate more similarly to public entities than consumers regarding spending.

reading in each year as well. I aggregate these data to the school district-year-level to merge with financial data, and they provide very granular measures of school district-level student characteristics.

Table 1 provides a summary of district-level per pupil special education spending, teacher salaries, student achievement, and student demographics for my analytic sample and separately for districts separated by income. In this table and in subsequent analyses, I separate districts by the median level of economic disadvantage during my sample period. Formally, I calculate the median proportion of non-economically disadvantaged students in a district from the district-year-level sample, and classify districts as above or below this threshold. Above the threshold implies above-median or high-income, and below this threshold implies low-income. This definition allows districts to change low- and high-income status during the panel.

The average school district spent \$1,447 for special education annually per-pupil in 2025 dollars during my sample period. Low-income school districts spent slightly more per pupil on average during this time, although these school districts have lower average teacher salaries as well. The average teacher's annual salary during my sample period was \$74,809 in 2025 dollars, although the average annual teacher salary was \$71,970 in low-income school districts.

Considering student demographic data, the third panel of Table 1 presents the average standardized math scores for Michigan students during my sample period, and these are standardized within each grade and year. Due to my sample restrictions, this standardized average is slightly less than 0. In addition, low-income school districts have much lower standardized test scores relative to high income school districts.

The bottom panel of Table 1 describes other demographic characteristics. The average school district enrolled 2,891 students during my sample period, and high-income school districts were larger on average relative to low-income school districts. Among all districts, 52.6% of students were economically disadvantaged, 3.5% of students were identified as English learners, and 14.7% of students were identified with disabilities. This 14.7% of students with disabilities was comprised of 5.2% students with a specific learning disability (SLD), 3.8% with a speech and language impairment (SLI), 2% with another health impairment (OHI) including ADHD, and the remaining students are identified with a cognitive impairment, emotional impairment, or another less common disability. Disability proportions are relatively similar between high- and low-income school districts, with the exception of cognitive impairments which are significantly more common in low-income school districts.

Several disability categories have incidences of less than 1% in Michigan school districts on average. As a result of both the low incidences of these disabilities and the highly specialized nature of services for these students, I combine all students with these disabilities into a single "other severe disability" in my analyses. Given the variable needs of these students, making inferences about the expenditures in these categories from these data could be misleading (Gronberg et al., 2005).

Table 2 presents a summary of district-level demographic data for students with disabilities in my sample. The first column of this table presents averages for students without disabilities, and subsequent columns describe the proportions of students with each disability who are female, economically disadvantaged, English learners, and identify as a non-White race or ethnicity.[9] Boys comprise a larger proportion of students with disabilities than they do in the broader population, and students identified with disabilities are more likely to be economically disadvantaged on average.

Notably, these averages hide substantial variation within disabilities. Students with cognitive and emotional impairments are 19 and 21 percentage points more likely to be economically disadvantaged than non-SWDs respectively whereas students with Autism are only 3 percentage points more likely to be economically disadvantaged. Similarly, students with cognitive impairments and specific learning disabilities are comprised of more non-White students relative to the average non-SWD, and students with Autism are more likely to be White.

In addition to these averages, Figure 1 presents medians, interquartile ranges, and the 10th and 90th percentiles of the proportion of time spent in push-in or pull-out special education programs separately for each disability category. The y-axis of this figure is derived from student-level special education FTEs which describe the proportion of 1,098 minimum total instructional hours during which a student received special education programming. In this figure, students with speech and language impairments (SLI), other health impairments (OHI), and specific learning disabilities (SLD) have the lowest median proportions of time spent receiving special education programming. In particular, the median number of hours spent in special education services is 0 for students with SLI, and this graph plots the interquartile range for this disability at 0.

In contrast, students with Autism, other severe disabilities, and cognitive impairments have the highest proportions of each school day spent receiving some form of special education programming. Figure 1 demonstrates that emotional impairments, Autism, other severe disabilities, and cognitive impairments all have wide variation in the level of need for students identified with these disabilities. Further, it is important to note that this graph only plots

[9] Here, I use White students as the reference category as the majority of Michigan students identify as White. Nevertheless, recent research has identified alternative ways of categorizing race that does not involve dummy coding with a reference category, and using alternative categorizations could illuminate other trends in identification (Mayhew & Simonoff, 2015).

push-in or pull out time with a special education teacher or paraprofessional. Students with disabilities may have access to supplementary services such as a speech pathologist or school psychologist during the school day, or they may also receive accommodations for their disability that do not comprise time spent in special education programming.

Figure 2 presents counts of students with each disability during my sample period.[10] The total count of students with disabilities declined in Michigan between the 2011-12 and 2021-22 academic years, although special education identification increased beginning in the 2021-22 academic year (Hopkins et al., 2024). In addition, there were substantial increases in the number of students identified with Autism and other health impairments including ADHD following the COVID-19 pandemic. In contrast, the number of students identified with other disabilities have remained relatively stable over time.

3.2 Estimation Strategy

To understand the relationship between disability category labels, student achievement, teacher salaries, student demographics, and school district spending, I estimate a stochastic frontier model of per pupil spending on teacher salaries, student achievement, and student demographics following Gronberg et al. (2005), Imazeki (2008), Gronberg et al. (2011), Gronberg et al. (2015), and Taylor et al. (2023). My primary model takes the following form:

$$\begin{aligned} \ln(AvgSpedExp_{it}) &= \beta_1 \ln(AvgTeacherSalaries)_{it} + \beta_2 MathScore_{it} \\ &+ \beta_3 \ln(Enroll_{it}) + \mathbf{\Omega}\mathbf{X}_{it} + \delta_t + u_{it} + \nu_{it} \end{aligned} \tag{1}$$

For each district i and year t, $AvgSpedExp$ represents the average per pupil special education expenditures, $AvgTeacherSalaries$ represents average annual teacher salaries, $MathScore$ represents the average standardized math score on state standardized tests,[11] $Enroll$ represents the total enrollment headcount, $\mathbf{X}$ represents a matrix of student demographic proportions in the district including the proportion of economically disadvantaged students, the proportion of English learners, and the proportion of students in the seven disability categories identified in Table 1, and δ_t represents a vector of year indicators. In this model, I include average state standardized tests as a measure of district-level educational output, and in some robustness checks, I replace this with the average standardized math score only for students with disabilities in a district. If higher standardized tests scores are

[10] This figure includes headcounts from the 2019-20 academic year, although observations from this year are excluded from my analytic sample due to a lack of state testing during the COVID-19 pandemic.

[11] Michigan used the Michigan Educational Assessment Program (MEAP) until 2013, and the state transitioned to using the Michigan Merit Exam (MME) and the Michigan Student Test of Educational Progress (M-STEP) in the 2013-14 academic year. In this study, I use average standardized score as opposed the proportion of students proficient as proficiency criteria changed when Michigan transitioned to MME and M-STEP.

associated with greater expenditures, this variable will control for that variation (Gronberg et al., 2005, 2011). Following prior research on education cost functions, I include interactions and squares of all covariates as well. For notational simplicity, squares and quadratics are not shown in Equation 1. The full estimating equation is presented in Appendix 2 along with additional estimation details. I cluster all standard errors at the school district-level.

Notably, prior research on education cost functions strongly indicates that school districts vary in their levels of spending efficiency. Efficient spending is defined as the minimum spending necessary to achieve an educational outcome, and researchers have used many different approaches to controlling or estimating the level of efficiency in education spending (Costrell et al., 2008; Grosskopf et al., 2017). Inefficiency could bias estimates in Equation (1) if district-level spending inefficiency is correlated with covariates. To account for this, I estimate a stochastic frontier model of district spending, and I explicitly model the inefficiency in the error term as u. This component of the error term is assumed to take on strictly positive values, so greater inefficiency is assumed to increase special education expenditures.

While this model is both flexible and theoretically grounded, numerous researchers have noted that this model is unintuitive. The many parameters require interpretations accounting for the nonlinearity in the model, and the log-linear interpretations of proportional variables are not straightforward. To ease interpretation, I present estimates of the effect of a one student increase for each of the demographic categories in my data on the conditional mean of total spending.

This is illustrated in Figure 3 using the proportion of students with a speech and language impairment as an example. First, I estimate Equation (1) using all squares and interaction terms, and I predict the per pupil expenditures for the average district. This is defined as the predicted per pupil special education expenditures when all covariates are set equal to their averages from Table 1, and this average district would be predicted to spend $1,339.80 per pupil for special education during my sample period. This is notably lower than the average expenditure in Table 1, and this difference is the result of outlier districts biasing the raw average of per pupil special education expenditures.

After I define this "average" district, I predict district-level per pupil expenditures with all variables at their averages, except that I add one student to the count of students with speech and language impairments.[12] In Figure 3, an otherwise average district with

[12]Formally, the model in Equation (1) incorporates proportions of students with disabilities and not counts by disability. To calculate the 1-student difference in expenditures above, I calculate the change in the proportion of students in a disability category associated with a 1 student increase, or a 1/2864 increase in the special education proportion. As this approach holds the log of student enrollment constant, this only varies the number of students with the disability and does not change the denominator of the per pupil expenditure calculation.

one additional student with a speech impairment would be predicted to spend \$11,676.60 per pupil, \$1.30 per pupil more than the average district. Multiplying this change in per pupil spending by the total number of students in the average district (2,864 from Table 1) gives the total predicted dollar increase in spending associated with this one student change of approximately \$4,496.[13] I calculate standard errors for this prediction using the delta method.

This approach gives a per pupil estimate of the additional expenditures associated with each disability. This is the estimate of excess expenditures, or the expenditures above those for a student without disabilities. The comparison in this model would be to not change the number of students with disabilities, and this would be associated with a \$0 change in spending.

Notably, estimates from this model should be interpreted as descriptive expenditure changes, and not as causal "cost" estimates (Costrell et al., 2008; Hanushek, 2007). While the stochastic frontier model in Equation (1) models spending inefficiency and controls for many drivers of school spending, teacher salaries, student achievement, and student demographics are not randomly distributed in the population. Nevertheless, to the extent that estimates from this model align with professional judgment estimates, they can provide evidence of spending trends that could be considered in special education finance and funding formulas more generally.

4 Results

4.1 Estimates of Additional Expenditures by Disability

Table 3 presents expenditure differential estimates from Equation (1) using a stochastic frontier model. The first panel of this table presents per-pupil special education expenditures in the average school district. This is the predicted per pupil expenditure with all covariates set equal to their averages, and this indicates that the average per pupil special education expenditure is \$1,339.80. This is less than the raw average in Table 1, and this suggests that this raw average is biased upwards by outliers and factors related to teacher salaries, student achievement, and characteristics of the student population.

The second panel of Table 3 presents predicted additional expenditures that would result from increasing the enrollment of students in each disability category by one student. Increasing the number of students in a school district by 1 student with a cognitive disability would increase total predicted special education spending by \$14,947. Similarly, increasing

[13] Estimates in this example do not correspond exactly to estimates in Table 3 due to rounding.

the count of students with emotional impairments by 1 student would increase predicted spending by $20,205. In other words, Michigan school districts spend $20,205 more per pupil on average for students with emotional impairments relative to students without disabilities.

Considering speech and language impairments and specific learning disabilities, school district expenditure estimates are less responsive to enrollment changes in these groups. School districts would be predicted to increase expenditures by $4,492 more for students with SLI, and they would be expected to increase expenditures by a smaller $1,998 for each student with SLD. These differences align with prior research as students with SLI and SLD spend more time in general education classrooms than students with other disabilities on average (Chambers et al., 2005; Parrish et al., 2015). This is also evidenced by Figure 1 as students with these disabilities spend less time in push-in and pull-out services relative to students with other disabilities.

Considering Autism and OHI, my model estimates larger expenditures associated with serving students with these disabilities. If the average school district were to gain one additional student with Autism, my model indicates that they would spend $22,263 above what they would spend for a student without Autism. These additional expenditures may support Autism specialists or other staff that specifically support services for these students. Similarly regarding OHI, a school district would be expected to spend an additional $12,129 for an additional student with ADHD or another health impairment.

4.2 Robustness Checks and Alternative Specifications

Appendix Table A2 presents marginal effects from all model covariates, and Appendix Table A3 presents translated dollar effects from a 1-student increase in each of the student categories. These table includes estimates from an OLS model of Equation (1), a Poisson regression which directly models the non-negative dependent variable, and the stochastic frontier model from Table 3. Marginal effect estimates and dollar estimates are very consistent across specifications. This suggests that incorporating the inefficiency term in the error has a very small effect and does not strongly impact the main estimates.

In addition to Appendix Tables A2 and A3, Appendix Table A4 presents robustness checks of my main estimates with a variety of specifications. This table includes estimates using a stochastic frontier model with district-level enrollment weights, a model without charter schools, models incorporating measures of distance from urban centers, a model with a cubic term for size of enrollment, and a model that changes the threshold of enrollment for districts to be included in my sample. Model estimates are very consistent across specifications in this table.

Except for SLI and SLD, enrollment weighting leads to larger estimates of expenditures associated with different disability labels. With enrollment weighting, school districts would be predicted to increase spending by \$32,314 and \$43,873 for students with Autism and other severe disabilities respectively relative to \$22,263 and \$23,978 without enrollment weighting. As special education funding is organized at the school district-level, I prefer the unweighted estimates in Table 3 as these better capture expenditures for the average district. However, it is important to note that these expenditure estimates may represent lower bounds of expenditures, and larger school districts would be estimated to increase spending more for these disabilities.

Notably, enrollment weighting causes the expenditure estimate for a 1-student increase in SLD to become negative. While this estimate is not statistically significant, this suggests that school districts could spend less in total special education expenditures with one additional student with SLD. This may seem counterintuitive, although this could be feasible if a small number of students with SLD are served in many different classrooms, and increasing the number of students with SLD leads school districts to prioritize one teacher or staff member to implement SLD programs and administration. In addition, some research demonstrates that larger school districts are better able to provide interventions and coaches in general education, and this may reduce the need for the identification of students with SLD overall (Senkowski, 2024). Nevertheless, as this estimate is very noisy, this finding is only suggestive.

Beyond the alternative model specifications in columns (1)-(7) of Appendix Table A4, columns (8) and (9) of this table present alternative sample specifications as well. Column (8) presents estimates of Equation (1) adding the average standardized math score among students with disabilities to the model. As expenditures for special education should only be used to support SWDs, this may be a more accurate output measure, although estimates are consistent between this specification and the base specification.

Column (9) of Appendix Table A4 adds a proportion of ISD-level special education expenditures to each school district's special education expenditures as well as students enrolled in ISD-run centers to the proportions of SWDs in each district. As ISD expenditures support multiple districts, these expenditures are added in equal proportions to each constituent district's special education expenditures. This specification provides substantively different trends than the base specification. Expenditures for emotional impairments, SLI, and Autism are smaller than the base specification, and this may reflect the fact that ISDs support specialists for these disabilities (e.g. school psychologists, speech pathologists, and Autism specialists) that travel between districts. These specialists may vary their time spent in different districts, and this flexibility may allow specialists to increase their time in a district in the event of an increase of 1 student with SLI or Autism. In this case, this flexibility may absorb the change in enrollment without a corresponding change in expenditures.

Conversely, estimates for SLD and OHI are higher in column (9) of Appendix Table A4 than the base specification. Local school districts serve a very small proportion of students with severe SLD or OHI, and these students may be more likely to be served in a dedicated ISD center for special education given their complex needs. As a result, the addition of one student with one of these disabilities may increase total special education expenditures more than would be expected based only on district-level expenditures. As the enrollment of SWDs in ISD-run centers is highly variable and the financial ability of an ISD to support school districts also varies substantially, I prefer estimates in Table 3 that do not incorporate ISD-level expenditures. That said, it is important to note that different ISD-level characteristics may change the estimated total expenditures associated with different disabilities.

In addition to robustness checks of my main estimating equation, I also estimate panel versions of Equation (1) with fixed effects in Appendix Table A5. This table presents estimates from an OLS model, Poisson regression, and a stochastic frontier model all with school district dummy variables, and all models also include time dummies. Estimates in this table are directionally similar to my main estimates, although these are smaller in magnitude. Considering column (4) of Appendix Table A5, the stochastic frontier model with fixed effects indicates that a school district would increase special education expenditures by \$5,772 for an additional student with a cognitive disability relative to \$14,947 in my model without fixed effects. Similarly, column (4) of Appendix Table A5 indicates that school districts would only increase spending by \$12,993 for an additional student with Autism relative to \$22,263 in my main model.

Although panel data estimates are more conservative than those in my main model, I prefer pooled estimates in Table 3. As evidenced by Table 2, students with disabilities are not randomly distributed across school districts. As a result, school districts may specialize or have greater experience serving particular disabilities due to the most common disabilities in their student body. Fixed effects net out any savings from this potential specialization of school districts, although this gives a worse prediction of expenditures for the average school district.[14] As a result, I prefer the larger estimates in Table 3, although predicted spending changes may vary by district-specific characteristics.

Expenditure estimates for special education in Table 3 align with prior estimates of

[14]For example, a school district that specializes in serving students with Autism may not change spending as dramatically to serve an additional student with this disability, and estimates from Appendix Table A5 may provide a more accurate representation of their additional expenditures. Nevertheless, as the average district likely does not specialize in serving students with Autism, estimates from Table 3 may be more representative of the potential change in expenditures.

special education expenditures in real dollar terms. Table 4 provides a comparison of estimates of the expenditures associated with special education across studies. The first column in this table presents the estimated additional expenditures associated with each disability category from Table 3, and columns (2) and (3) present expenditure estimates from Chambers et al. (2005) and a recent cost study in Michigan (Augenblick, 2019). Weighted averages of spending represent averages weighted by the proportion of each disability in Michigan.

Expenditure estimates from Equation (1) are directionally aligned with estimates from Chambers et al. (2005), although estimates for SLD are substantially smaller than the nationwide average. This is likely due to two factors. First, students with this disability spend disproportionately less time in special education programs relative to other students with disabilities in Michigan. This is illustrated in Figure 1. Given that many students with this disability during my sample period were not provided any dedicated special education programs outside of general education accommodations, this may decrease the estimated expenditure change associated with this disability. Second, this difference may also be the result of changes in identification procedures and declines in the identification of students with this disability over time, although these changes may not have affect a large proportion of Michigan students (Senkowski, 2024).[15]

In addition to these differences, cost function expenditure estimates are all lower than the funding adequacy estimates from the 2025 Michigan Blueprint. These funding adequacy estimates in this report are drawn from professional judgment and adapted adequacy estimates in Ohio, and Michigan educators may make different decisions regarding how to allocate resources for special education. Nevertheless, these differences suggest that the current system of special education finance may not support school districts to spend adequately for special education. Weighting disability expenditure estimates by each disability's proportion of Michigan's special education population, cost function estimates indicate that school districts spend an additional $8,483 for the average student with a disability in Michigan. This is lower than both the nationwide average of $12,939 in Chambers et al. (2005) and half of the average funding amount of $16,457 recommended in the Michigan Special Education Blueprint (Autism Alliance of Michigan & Public Sector Consulting, 2025).

4.3 Characteristics of Disabilities Associated with Expenditures

In addition to differences in expenditures by disability, I also explore how estimated spending for special education varies with school district-level economic disadvantage. This comparison is motivated by evidence that White students tend to receive "higher status" disability

[15]Notably, Michigan was not included in Chambers et al. (2005)'s original sample of states. As a result, differences in spending may also reflect differences in the needs of Michigan students relative to other states.

identifications including speech and language impairments, other health impairments including ADHD, and Autism (Daysal et al., 2024; Fish, 2019). Demographic averages in Table 2 indicate that differences in identification are not driven by race in my sample, but if wealthier students are more likely to receive specific disability identifications, then expenditures for these disabilities could be biased.

Table 5 presents estimates from my main model in column (1), estimates for low-income school districts in column (2), and estimates for high income school districts in column (3). As in Table 1, low-income school districts are those that have an average level of non-economic disadvantage that is below the median district in the sample. This table decomposes the estimates from the main model into the effects driven by both types of districts, and overall estimates in the base model comprise weighted averages of these estimates.

Disaggregating estimated expenditure differences by school district-level economic disadvantage reveals substantial differences in spending by type of district. For example, a 1-student increase in students with emotional impairments increases predicted spending in low-income school districts by \$15,365, but this would increase predicted spending by \$25,262 in a wealthier school district. A similar trend holds for students with Autism, other health impairments, and other severe disabilities impairments as higher-income school districts increase spending more relative to lower-income school districts.[16]

To understand the drivers of differences in estimated expenditures, Figure 4 presents averages of the proportions of students identified in each disability category by school district income decile. The top panel of this figure presents all disabilities, and the primary trend is that students with SLI and SLD are identified at lower rates in high-income school districts. This aligns with averages of economic disadvantage for these groups in Table 2 as well as Ainsworth et al. (2026) who find that wealthier students are more likely to receive 504 plans instead of IEPs.

The lower panel of Figure 4 presents a subset of the top panel as it is difficult to observe differences in these due to their lower incidence. Here, trends emerge for both cognitive and emotional impairments as these disabilities are less common in higher-income school districts. This implies that the lower expenditure estimates for these disabilities in Table 5 may be driven by the prevalence of students with these disabilities in lower-income school districts. Conversely, the prevalence of Autism increases with school district wealth, and this could

[16] Notably, as economic disadvantage is higher in the sample of low-income school districts and economic disadvantage is positively correlated with spending, estimates in low-income school districts may be mechanically driven by higher averages of covariates. To address this concern, Appendix Table A6 re-estimates the model for low-income and high-income school districts redefining low-income districts by the average property value in each district. Results are substantively similar, except that expenditures for cognitive impairments are slightly higher in lower-wealth school districts. As property tax value is not included in the regression model, this demonstrates that the trends are not mechanically driven by covariate averages.

explain larger expenditure estimates if students with Autism sort into those districts following Fish (2019) (see also Fuchs et al. (2025)). Like Fish (2019), I cannot test the directionality of this enrollment, although future research should explore whether students with "higher status" disabilities sort into wealthier school districts or whether wealthier school districts are more likely to identify students with these disabilities.

In addition to differences in the distribution of disabilities across school districts, districts also vary dramatically in the types of expenditures reported for special education. Figure 5 presents per pupil averages of special education expenditures separated by school district income decile. Here, bar stacks represent the per pupil expenditures for each of special education teachers, special education specialists including speech pathologists, school psychologists, social workers, or other specialists, indirect costs, or expenditures for general education that support special education, classroom aides or paraprofessionals, teacher consultants, and administration. Due to data limitations, per pupil expenditures are only reported in this granular way beginning in the 2016-17 academic year. Nevertheless, total average per pupil special education expenditures (represented by the full height of each bar) are similar to the $1,447 average for all districts in Table 1.

This bar graph illustrates a U-shaped trend in total special education spending across school districts by income decile. On average, districts with the most economically disadvantaged students and districts with the fewest economically disadvantaged students spend the most per pupil on special education, and districts in the middle of the income distribution spend less per pupil. This indicates that expenditure differences in Table 5 are largely driven by these outlier districts.

In addition to differences in total spending, Figure 5 indicates that the lowest-income districts spend more per pupil for special education teachers and specialists, whereas wealthier districts spend more for classroom aides and teacher consultants. As classroom aides may be less expensive and easier to hire relative to special education teachers and specialists, this may allow higher-income school districts to be more flexible to increase or change expenditures when they enroll a new student with a disability. Alternatively, wealthier parents may prefer that their students spend more time in general education classrooms rather than self-contained special education classrooms, and they may advocate for greater hiring of paraprofessionals. In either case, this may explain why predicted changes in expenditures are estimated to be higher in wealthier districts relative to less wealthy districts in Table 5. Similarly, as lower-income school districts spend more per pupil for special education teachers and specialists, these individuals may be more difficult to hire when a new SWD is identified, and spending may be less reactive and flexible in these districts.

5 Discussion

Substantial research finds that special education services are expensive, and there is high variation in expenditures across disability categories (Parrish et al., 2015). Estimating a cost function for special education in Michigan, I find that excess expenditures for students with disabilities range from $1,998 for a student with a specific learning disability to $23,978 for a students with a low-incidence disability. These estimates are lower than what is recommended in the Michigan Blueprint, and they vary dramatically by school district characteristics as well. Estimates of expenditures such as these easily translate into per pupil weights that policymakers can adapt for state-level special education funding, although my estimates of current expenditures are generally lower than recent adequacy estimates for special education funding in Michigan (Augenblick, 2019; Autism Alliance of Michigan & Public Sector Consulting, 2025).

Notably, estimates of special education expenditures are heterogeneous across school districts, and disability categories are not evenly distributed across the state. Higher-income school districts tend to increase expenditures more for emotional impairments, Autism, and other health impairments including ADHD relative to lower-income districts. For emotional impairments, this trend may be the result of differences in service delivery between high- and low-income school districts. Research demonstrates that wealthier parents have strong preferences for schools to organize self-contained classrooms for students with disabilities (Drake, 2020), and Dishion and Tipsord (2011) suggest that this practice may have negative social and academic consequences for students with emotional and behavioral disorders. Further, researchers have identified effective strategies for educators to teach students with behavioral disorders adaptive social behavior skills in general education classrooms (Dishion & Tipsord, 2011; Franklin-Gillette et al., 2023). Future research should explore the mechanisms for higher expenditures in wealthier districts for these students as well as approaches to support the inclusion of students with emotional and behavioral disorders in the classroom.

For Autism and OHI, higher expenditures in wealthier districts may be a function of endogenous sorting of students into school districts or endogenous identification of students with specific disabilities in high and low-income school districts following Fish (2019). Higher rates may be due to wealthier families' advocacy for higher status disability labels of Autism instead of cognitive impairment and ADHD instead of emotional impairment (Daysal et al., 2024; Fish, 2019). Further, wealthier families may seek outside resources like neuropsychological evaluations to obtain the higher status diagnoses of Autism and ADHD and bring those diagnoses to the school.

As disability identifications are not random, it may be difficult for research to disentangle this endogeneity and identify the true "costs" of special education. For example, as estimates of the expenditures associated with Autism are primarily derived from wealthier school districts, these estimates may not capture the resources required to provide services for the average student with Autism. Further, higher-income school districts tend to spend more per pupil for special education classroom aides and teacher consultants relative to lower-income school districts. This may be due to the greater ability of these districts to hire paraprofessionals or other special education staff and the higher average salaries offered in these districts. Future research on special education finance should be cognizant of these effects and consider the interplay between income, disability identification, and school spending. Simulation studies or studies of special education identification and sorting may be valuable to help separate these effects.

In addition to implications for research, the variation in expenditures for special education suggests that the use of flat or uniform weights in school finance may not appropriately support school districts to provide services. For example, a cost function approach suggests that a student with Autism requires more funding both because of the services they need and because the school has the means and social pressure to provide specific services in a higher-income school district. Differences in spending by district characteristics could reflect differences in district preferences for special education, or they could reflect a differential ability to support students with disabilities. In either case, a uniform weight for students with Autism may only serve to reinforce income-driven differences in special education spending across districts. Policymakers working to improve equity in special education funding could consider implementing dynamic weights that vary not just with characteristics of students but with the characteristics of school districts as well. Such weights could better capture heterogeneity in district preparation to serve specific disabilities and student needs.

Notably, Michigan's current system of reimbursement for special education expenditures avoids these issues as all expenditures are reimbursed regardless of the disabilities a school district serves. As a result, schools are not incentivized to identify students with more or less expensive disabilities (Ballis & Heath, 2021; Mahitivanichcha & Parrish, 2005). In addition, Figure 1 illustrates that there is substantial variation in student need for special education programming even within disability categories, and a reimbursement approach scales more easily to support this variation. As a result, the reimbursement approach may be more effective for supporting students with disabilities relative to a weighted funding formula in Michigan.

6 Conclusion

Using a 13-year panel of school districts in Michigan, this paper estimates the additional expenditures associated with different disabilities in Michigan. Following prior research, I find substantial heterogeneity of expenditure estimates for students with disabilities. Increasing the number of students with disabilities by 1 student in the average school district is associated with an increase in expenditures between $1,998 for students with specific learning disabilities to more than a $23,000 increase in expenditures for students with low-incidence disabilities and complex needs. While these estimates align with prior research on expenditures associated with different disabilities, I find evidence that these may be driven by a higher prevalence of high-status disabilities in wealthier school districts. Future research should consider the ways in which this sorting of students influences equity in education funding and students' outcomes, and policymakers should explore funding approaches in that address this heterogeneity.

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7 Tables and Figures

Table 1: District-Level Averages of Outcome Measures and Student Characteristics, 2011-12 through 2024-25

	All Districts	Low-Income Districts	High-Income Districts
Dependent Variable			
Average Per-Pupil SWD Expenditure	\$1,447	\$1,457	\$1,438
Input Prices			
Average Teacher Salary	\$74,809	\$71,970	\$77,648
Outcomes			
Standardized Math Score	-.002	-.214	.211
Student Characteristics			
Percent High School	.334	.334	.333
Percent of High Schoolers in AP/IB Courses	.152	.0985	.205
Average Total Enrollment	2864	2397	3332
Percent Economically Disadvantaged	.525	.685	.365
Percent English Learners	.0349	.0508	.0191
Percent Special Education	.147	.158	.136
Percent Cognitive Impairment	.010	.012	.007
Percent Emotional Impairment	.008	.009	.007
Percent Hearing Impairment	.001	.001	.002
Percent Visual Impairment	.000	.001	.000
Percent Physical Impairment	.001	.001	.001
Percent SLI	.038	.040	.036
Percent Early Childhood	.003	.003	.002
Percent SLD	.052	.057	.046
Percent Multiple Disabilities	.001	.001	.000
Percent Autism	.012	.012	.011
Percent TBI	.000	.000	.000
Percent Deaf/Blind	.000	.000	.000
Percent Other Health Impairment	.020	.020	.020
Observations	5,700	2,850	2,850

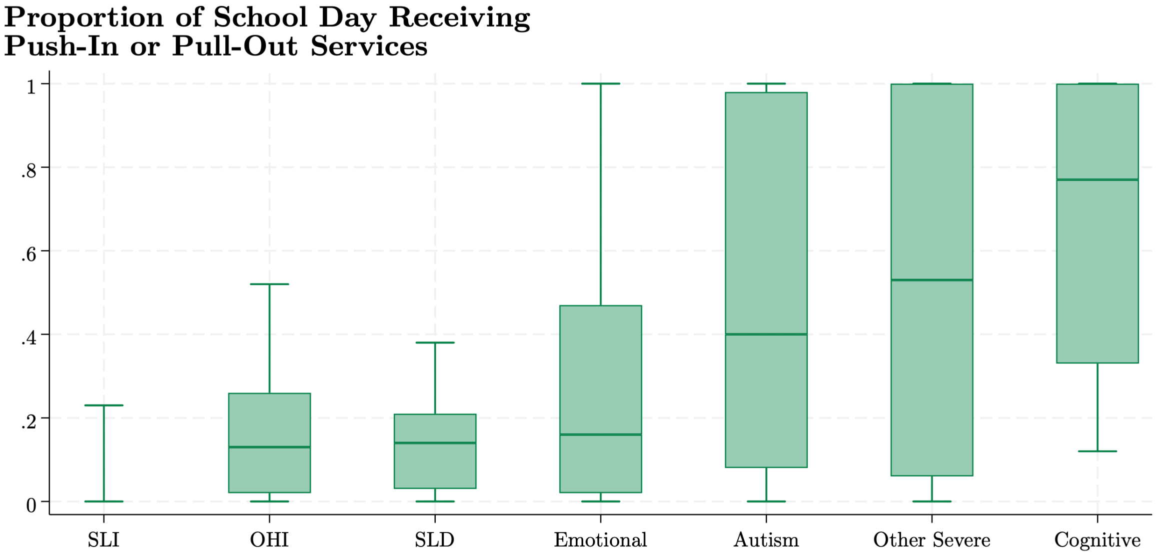
Notes: District-level averages of per pupil operating expenditures, student demographics, enrollment, achievement, and teacher salaries. Student-level data are aggregated from student-level annual administrative data in each school district. Values are pooled over the entire sample period except for the 2019-20 academic year as test scores are not available for this year. Average per pupil operating expenditures and teacher salary data are reported in annual Bulletin 1014 reports for each school district and published by the MDE. Disability categories with asterisks are grouped into "other severe disabilities" in subsequent analyses due to low incidence. All dollar values are adjusted for inflation using the GDP S&L price deflator to constant 2025 dollars.

Table 2: Average District-Level Special Education Demographics by Disability, 2011-12 through 2024-25

	Non-SWD	Cognitive	Emotional	SLI	SLD	Autism	OHI	Other
Proportion Female	.508	.425	.266	.342	.406	.160	.306	.377
Proportion Economically Disadvantaged	.504	.708	.727	.629	.683	.540	.637	.616
Proportion English Learners	.035	.036	.011	.039	.041	.024	.019	.031
Proportion Black	.093	.135	.099	.089	.119	.084	.105	.096
Proportion Hispanic/Latino	.073	.068	.054	.080	.083	.059	.056	.072
Proportion Asian	.017	.011	.003	.012	.005	.016	.005	.021
Proportion Other Non-White Race/Ethnicity	.048	.056	.062	.058	.054	.050	.057	.054
Student Count	2457	31	23	103	132	39	57	23

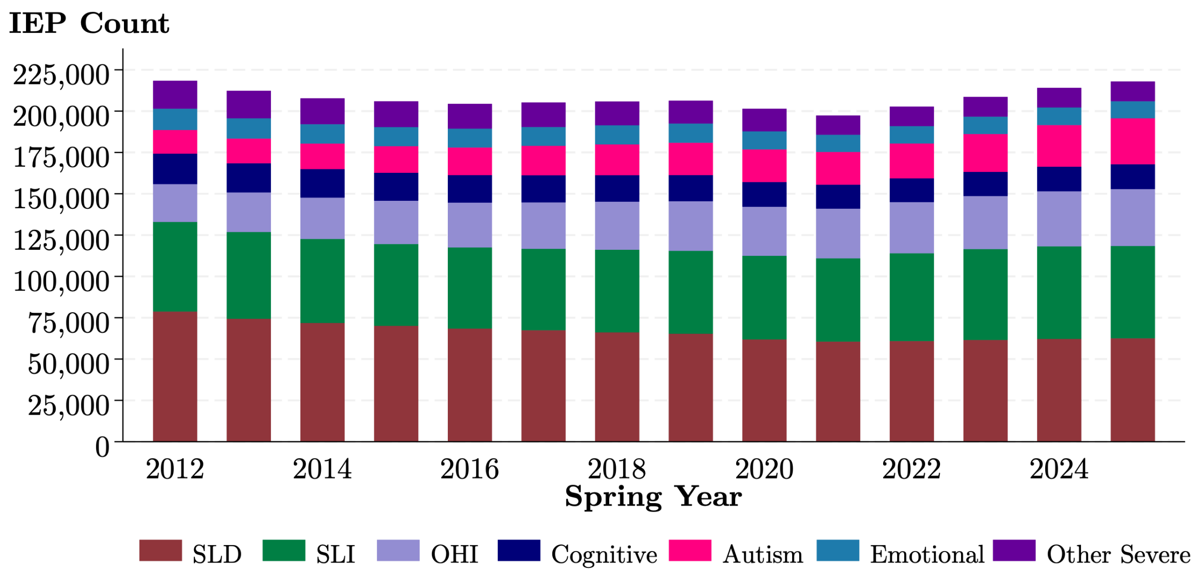
Notes: District-level averages of student demographics for full sample, separated by disability. Columns represent disability categories for students without disabilities and students with cognitive impairments, emotional impairments, speech and language impairments (SLI), specific learning disabilities (SLD), Autism, other health impairments (OHI), and other severe disabilities including hearing, visual, early child, multiple, traumatic brain injury, and deaf/blind impairments.

Figure 1: Average District-Level Average Proportion of Time Spent in Special Education Programs by Disability Category



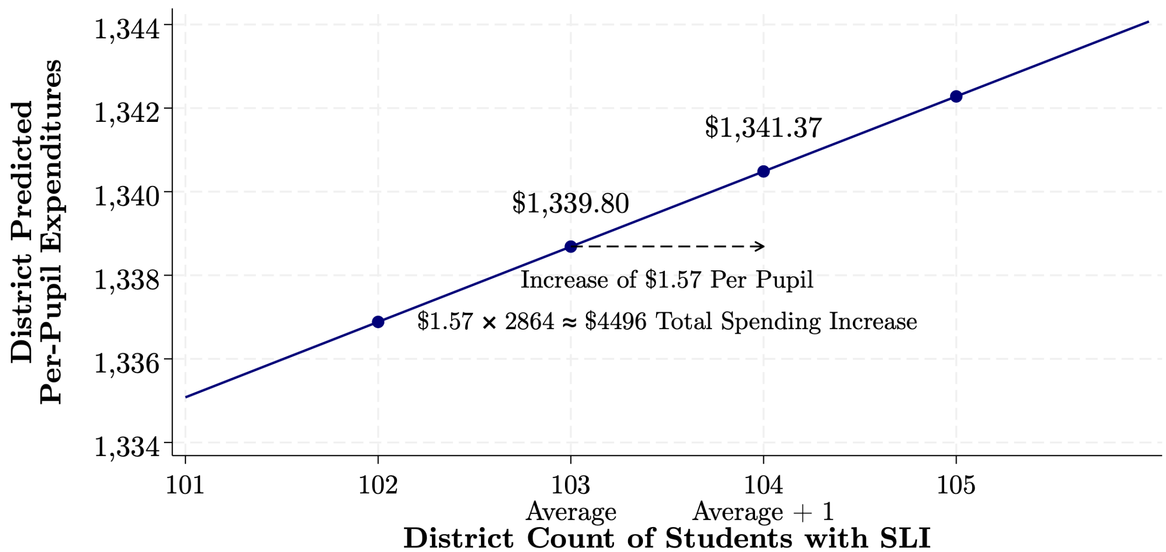
Notes: Averages of student-level fall special education FTEs by disability code, 2011-12 through 2024-25. 1 FTE is equivalent to a student spending 100% of their educational time in special education services.

Figure 2: Headcounts of Students with Disabilities by Disability, 2011-12 through 2024-25



Notes: Counts of students with disabilities by primary disability, 2011-12 through 2024-25. Counts only include those in Michigan traditional public school districts and charter schools who do not receive services in a dedicated special education center. Note that 2019-20 is displayed, but this year is omitted from the analytic sample as test scores are not available in this year. In the case that students are identified with multiple disabilities, they are counted only for the disability for which they have the highest special education FTE. Disability labels include specific learning disability (SLD), speech and language impairment (SLI), other health impairment (OHI), cognitive impairment, Autism, emotional impairment, other severe disabilities including hearing, visual, early child, multiple, traumatic brain injury, and deaf/blind impairments.

Figure 3: Example Calculation of SLI Expenditures Using Frontier Model



Notes: Example graph of additional expenditure calculation for students with speech and language impairments. First, Equation (1) is estimated using all covariates, squares of all covariates, and interactions of all covariates. Then, predicted per-pupil expenditures are calculated over a range of values of the proportion of students with SLI holding all other covariates constant at their averages. The average proportion of students with SLI corresponds to 103 students with SLI in the district (see Table 2). Subtracting the average per pupil expenditures from the predicted per pupil expenditures at the average plus one student with SLI gives the dollar amount different in per pupil spending associated with a 1 student increase in students with SLI. Multiplying by the average number of students in each district (2,864 from Table 1) gives the average total dollar increase associated with this change.

Table 3: Estimated Additional Expenditures Above Students without Disabilities by Disability Category

	(1) Frontier
Avg. Per Pupil Special Education Expenditure	$1,339.80^{***}$
	(26.606)
Additional Expenditures	
Cognitive Impairment	$14,947^{***}$
	(2,982)
Emotional Impairment	$20,205^{***}$
	(3,205)
Speech and Language Impairment	$4,492^{***}$
	(1,271)
Specific Learning Disability	$1,998^{**}$
	(956)
Autism Spectrum Disorder	$22,263^{***}$
	(2,912)
Other Health Impairment	$12,129^{***}$
	(1,901)
Other Severe Disability	$23,978^{***}$
	(3,500)
Total Districts	474
Observations	5,700

Notes: Estimated 1-student expenditure differentials from the fully specified model in Equation (1) estimated via a stochastic frontier model. Estimates represent total additional expenditures above those for a student without a disability. Sample includes all Michigan school districts with non-missing covariates between 2011-12 and 2024-25, excluding 2019-20 due to lack of test score data. Dollar values represent the difference between the total spending for the average school district plus one student in a given category and the total spending for the average school district. Standard errors clustered at the school district level. All dollar values are adjusted for inflation using the GDP S&L price deflator to constant 2025 dollars. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Comparison of Estimates of Additional Expenditures for Special Education by Disability Across Studies

Disability	Cost Function Estimated Expenditures	Chambers et al. (2005) Estimated Expenditures	2025 Michigan Special Education Blueprint Funding Adequacy Estimates
Cognitive Impairment	\$14,947	\$18,546	\$31,155
Emotional Impairment	\$20,205	\$16,594	\$38,190
Speech and Language Imp.	\$4,492	\$9,623	\$11,055
Specific Learning Disability	\$1,998	\$8,748	\$11,055
Autism	\$22,263	\$26,743	\$38,190
Other Health Impairment	\$12,129	\$14,587	\$18,090
Other Severe Disability	\$23,978	\$23,457	\$41,607
Weighted Average	\$8,483	\$12,939	\$18,336

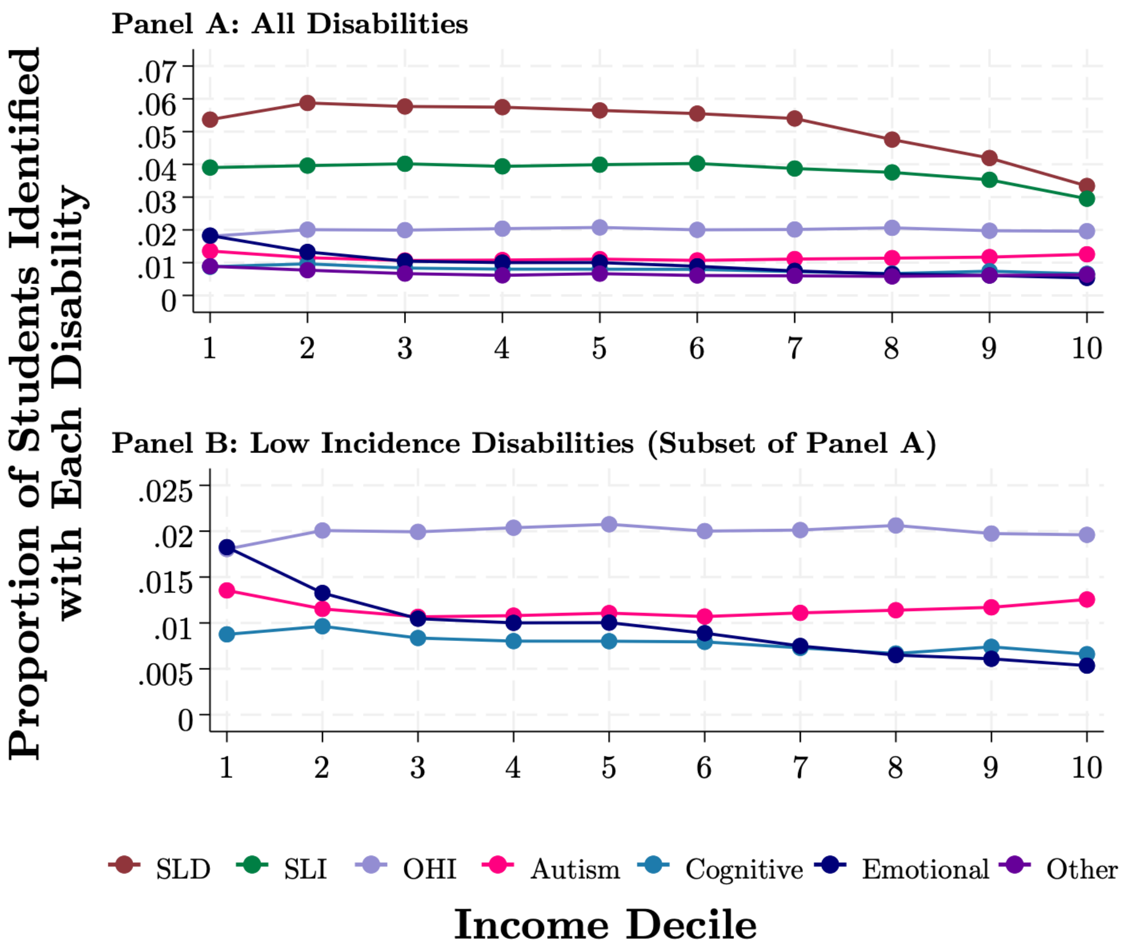
Notes: Comparison of additional estimated expenditures by disability across 3 studies. Expenditure estimates represent the expected total expenditure change associated with a 1 student increase in each disability category above the expenditure change for a student without a disability. Chambers et al. (2005) use a survey of state special education directors to derive their estimates, and Michigan was not included in this sample. The 2025 Michigan Special Education Blueprint uses a professional judgment approach in combination with adequacy estimates from Ohio to provide adequacy estimates of funding for Michigan students. Michigan Blueprint estimates calculated from recommended weights on top of the 2025-26 foundation allowance of \$10,050.

Table 5: Estimated Additional Per Pupil Expenditures by Disability Category, Heterogeneity by District Poverty Level

	(1) Base	(2) Below Median Income Districts	(3) Above Median Income Districts
Cognitive Impairment	$14,947^{***}$	$14,471^{***}$	$15,517^{***}$
	(2,982)	(3,004)	(3,914)
Emotional Impairment	$20,205^{***}$	$15,365^{***}$	$25,262^{***}$
	(3,205)	(3,581)	(4,190)
Speech and Language Impairment	$4,492^{***}$	$4,944^{***}$	$4,055^{**}$
	(1,271)	(1,329)	(1,739)
Specific Learning Disability	$1,998^{**}$	$2,055^{**}$	$1,949$
	(956)	(840)	(1,423)
Autism Spectrum Disorder	$22,263^{***}$	$20,055^{***}$	$24,647^{***}$
	(2,912)	(2,831)	(3,830)
Other Health Impairment	$12,129^{***}$	$10,649^{***}$	$13,710^{***}$
	(1,901)	(2,182)	(2,527)
Other Severe Disability	$23,978^{***}$	$17,445^{***}$	$30,791^{***}$
	(3,500)	(3,731)	(4,188)

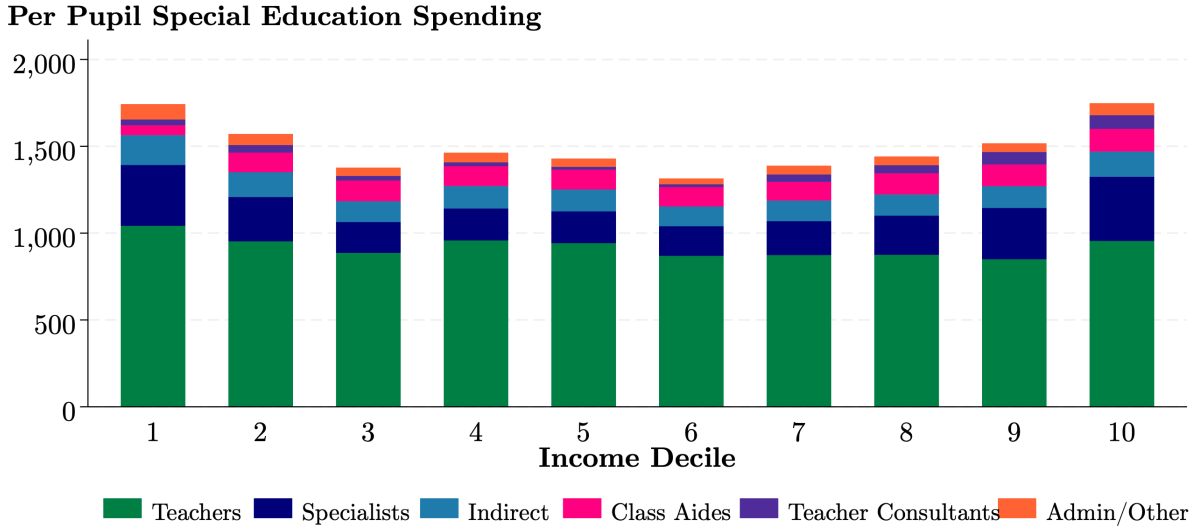
Notes: Estimated 1-student expenditure differentials from the fully specified model in Equation (1) estimated via a stochastic frontier model. Estimates represent total additional expenditures above those for a student without a disability. Sample includes all Michigan school districts with non-missing covariates between 2011-12 and 2024-25, excluding 2019-20 due to lack of test score data. Columns (2) and (3) provide estimates of expected expenditure changes separately for low income and high-income school districts defined by the proportion of economically disadvantaged students in the district. Dollar values represent the difference between the total spending for the average school district plus one student in a given category and the total spending for the average school district. Standard errors clustered at the school district level. All dollar values are adjusted for inflation using the GDP S&L price deflator to constant 2025 dollars. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 4: Average District Composition of Disabilities by District Income Decile



Notes: Average proportions of students identified with each disability by school district income decile. Data include the full sample of school districts between the 2011-12 and 2024-25 academic years. Deciles calculated from the average proportion of economically disadvantaged students in each year.

Figure 5: Average District Per Pupil Special Education Expenditures by Function and District Income Decile



Notes: Average per pupil special education expenditures separated by expenditure function and district income decile. Data include the school districts with sample restrictions between the 2016-17 and 2024-25 academic years. Deciles calculated from the average proportion of economically disadvantaged students in each district over the entire analytic sample period.

8 Appendix 1: Additional Tables and Figures

Table A1: Michigan Special Education Blueprint Weights

Disability	Funding Weight Recommendation	Funding Dollar Amount Recommendation
Speech and Language Imp.	1.1	$10,996
Specific Learning Disability	1.1	$10,996
Other Health Impairment	1.8	$18,087
Physical Impairment	3.1	$31,380
Severe Multiple Impairments	3.1	$31,380
Cognitive Impairment	3.1	$31,380
Deaf or Hard of Hearing	3.1	$31,380
Deaf/Blindness	3.1	$31,380
Emotional Impairment	3.8	$39,221
Visual Impairment	3.8	$39,221
Early Childhood Dev. Delay	3.8	$39,221
Autism Spectrum Disorder	3.8	$39,221
Traumatic Brain Injury	3.8	$39,221

Notes: Funding weights and funding dollar amount recommendations from the 2025 Michigan Blueprint for Special Education (Autism Alliance of Michigan & Public Sector Consulting, 2025).

Table A2: Marginal Effects from Alternative Specifications of Equation (1)

	(1) OLS	(2) Poisson	(3) Stochastic Frontier
Log Avg. Teacher Sal.	0.330***	535.394***	0.330***
	(0.088)	(123.957)	(0.087)
Standardized Math Score	0.002	45.778	0.002
	(0.055)	(74.056)	(0.055)
Log Student Enrollment	0.148***	179.210***	0.148***
	(0.024)	(29.891)	(0.023)
% Econ. Disad.	-0.353***	-510.078***	-0.353***
	(0.100)	(148.000)	(0.099)
% English Learner	1.358***	1828.626***	1.358***
	(0.327)	(462.371)	(0.324)
% Cognitive	11.170***	15479.426***	11.170***
	(2.238)	(2657.842)	(2.218)
% Emotional	15.042***	19573.318***	15.042***
	(2.386)	(3464.865)	(2.364)
% SLI	3.355***	2942.186**	3.355***
	(0.951)	(1241.240)	(0.942)
% SLD	1.498**	2131.057*	1.498**
	(0.721)	(1130.979)	(0.714)
% Autism	16.532***	28465.552***	16.533***
	(2.082)	(2940.409)	(2.063)
% OHI	9.035***	11134.047***	9.035***
	(1.411)	(1914.257)	(1.399)
% Other Severe Disability	17.781***	31076.135***	17.782***
	(2.556)	(3130.727)	(2.533)
Constant	14.228	11.810	14.228
	(50.055)	(43.768)	(49.159)
Log Likelihood	-1010.575	-295700.28	-1010.575
σ_u	-	-	0.001
ndists	474	474	474
N	5700	5700	5700

Notes: Marginal effects for all covariates from Equation (1). Column (1) represents estimates of expenditure changes using an OLS model, column (2) uses a poisson regression without taking the log of the outcome, and column (3) presents estimates from the stochastic frontier model in Table 2. Marginal effects represent the derivative of each covariate with all covariates centered at their means. Standard errors clustered at the school district-level. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Dollar Effects from Alternative Specifications of Equation (1)

	(1) OLS	(2) Poisson	(3) Stochastic Frontier
Econ. Disad.	-473^{***}	-438^{***}	-472^{***}
	(134)	(128)	(134)
English Learner	$1,820^{***}$	$1,669^{***}$	$1,819^{***}$
	(446)	(452)	(446)
Cognitive Impairment	$14,956^{***}$	$14,968^{***}$	$14,947^{***}$
	(2,983)	(2,650)	(2,982)
Emotional Impairment	$20,216^{***}$	$17,769^{***}$	$20,205^{***}$
	(3,206)	(3,320)	(3,205)
Speech and Language Impairment	$4,494^{***}$	$3,804^{***}$	$4,492^{***}$
	(1,272)	(1,115)	(1,271)
Specific Learning Disability	$1,999^{**}$	$2,187^{**}$	$1,998^{**}$
	(956)	(916)	(956)
Autism Spectrum Disorder	$22,276^{***}$	$25,415^{***}$	$22,263^{***}$
	(2,914)	(2,981)	(2,912)
Other Health Impairment	$12,136^{***}$	$11,702^{***}$	$12,129^{***}$
	(1,902)	(1,824)	(1,901)
Other Severe Disability	$23,992^{***}$	$28,252^{***}$	$23,978^{***}$
	(3,502)	(3,307)	(3,500)
Constant	441^{***}	420^{***}	441^{***}
	(96)	(85)	(96)
Total Observations	5,700	5,700	5,700

Notes: \$1 increase estimates for all covariates from Equation (1). Column (1) represents estimates of expenditure changes using an OLS model, column (2) uses a poisson regression without taking the log of the outcome, and column (3) presents estimates from the stochastic frontier model in Table 2. Marginal effects represent the derivative of each covariate with all covariates centered at their means, and these are rescaled following the procedure illustrated in Figure 3 to give dollar estimates. Standard errors clustered at the school district-level. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Robustness Checks of Special Education Expenditures

	(1) Base	(2) Enrollment Weighted	(3) No Charter Schools	(4) Binary Rural Indicator	(5) Log Distance to City	(6) Cubic of Enrollment	(7) 100 Student Enrollment Threshold	(8) SWD Math Scores	(9) ISD Special Education Exps.
Cognitive	14,947***	22,604***	14,147***	14,829***	15,175***	14,806***	13,711***	15,194***	15,913***
	(2,982)	(3,899)	(2,932)	(2,924)	(2,825)	(2,943)	(2,570)	(2,944)	(4,687)
Emotional	20,205***	24,933***	17,836***	20,119***	19,030***	19,322***	19,402***	19,385***	17,504***
	(3,205)	(5,769)	(3,319)	(3,225)	(3,037)	(3,194)	(2,675)	(3,197)	(4,618)
SLI	4,492***	3,056	4,113***	4,677***	4,312***	4,469***	4,603***	4,515***	395
	(1,271)	(2,116)	(1,253)	(1,269)	(1,199)	(1,255)	(1,084)	(1,236)	(1,825)
SLD	1,998**	-660	1,905**	2,008**	2,528***	2,213**	2,708***	2,277**	8,182***
	(956)	(1,735)	(944)	(929)	(913)	(941)	(788)	(928)	(1,447)
Autism	22,263***	32,314***	21,930***	21,483***	21,049***	21,799***	19,578***	21,975***	17,477***
	(2,912)	(4,370)	(2,865)	(2,857)	(2,719)	(2,885)	(2,523)	(2,858)	(4,634)
OHI	12,129***	16,637***	11,456***	12,482***	11,636***	11,793***	11,120***	11,511***	17,968***
	(1,901)	(3,310)	(1,886)	(1,862)	(1,840)	(1,892)	(1,545)	(1,886)	(3,023)
Other Severe	23,978***	43,873***	22,920***	23,699***	21,879***	23,608***	21,755***	23,431***	25,673***
	(3,500)	(5,250)	(3,427)	(3,488)	(3,351)	(3,451)	(3,140)	(3,391)	(5,000)
Constant	441***	428***	474***	420***	427***	426***	367***	436***	896***
	(96)	(85)	(104)	(91)	(92)	(92)	(82)	(97)	(168)
Log likelihood	-1,010.57	256,934	-933.9499	-962.8044	-893.2331	-997.1079	-1,845.39	-975.8507	-146.9685
σ_u	.0007147	.0000309	.0007439	.0007439	.000743	.0006832	.000646	.0007091	.0006373
ndists	474	474	456	474	474	474	545	474	474
N	5,700	5,700	5,644	5,700	5,699	5,700	6,667	5,698	5,700

Notes: Alternative specifications of estimated 1-student expenditure differentials from the fully-specified model in Equation (1) estimated via a stochastic frontier model. Sample includes all Michigan school districts with non-missing covariates between 2011-12 and 2024-25, excluding 2019-20 due to lack of test score data. Dollar values represent the difference between the total spending for the average school district plus one student in a given category and the total spending for the average school district. Standard errors clustered at the school district level and calculated via the delta method. All dollar values in adjusted for inflation using the GDP S&L price deflator to constant 2025 dollars. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Panel Estimates of Special Education Expenditures

	(1) Base Model	(2) OLS Fixed Effects	(3) Poisson Fixed Effects	(4) Stochastic Frontier Fixed Effects
% Cognitive	$14,947^{***}$	$6,223^{***}$	$6,478^{***}$	$5,772^{***}$
	(2,982)	(1,778)	(1,691)	(1,666)
% Emotional	$20,205^{***}$	$5,018^{**}$	$4,837^{**}$	$4,682^{**}$
	(3,205)	(1,988)	(1,925)	(1,822)
% SLI	$4,492^{***}$	$1,839^{***}$	$2,703^{***}$	$1,680^{***}$
	(1,271)	(637)	(694)	(596)
% SLD	$1,998^{**}$	$3,261^{***}$	$3,726^{***}$	$3,055^{***}$
	(956)	(669)	(661)	(621)
% Autism	$22,263^{***}$	$14,181^{***}$	$14,206^{***}$	$12,993^{***}$
	(2,912)	(1,920)	(1,697)	(1,784)
% OHI	$12,129^{***}$	$6,539^{***}$	$6,170^{***}$	$6,028^{***}$
	(1,901)	(1,171)	(1,086)	(1,110)
% Other Severe	$23,978^{***}$	$10,374^{***}$	$10,313^{***}$	$9,317^{***}$
	(3,500)	(2,343)	(2,338)	(2,156)
Constant	441^{***}	996^{***}	952^{***}	916^{***}
	(96)	(168)	(144)	(148)
Log Likelihood	-1,010.57	3399.4	-83,072.2	3,401.5
σ_u	.001	-	-	.100
Total Districts	474	474	474	474
Total Observations	5,700	5,700	5,700	5,700

Notes: Estimated 1-student expenditure differentials from the fully specified model in Equation (1) estimated via a stochastic frontier model. Estimates represent total additional expenditures above those for a student without a disability. Sample includes all Michigan school districts with non-missing covariates between 2011-12 and 2024-25, excluding 2019-20 due to lack of test score data. Columns (2) and (3) provide estimates of expected expenditure changes separately for low income and high-income school districts defined by the average property tax wealth in the district. Dollar values represent the difference between the total spending for the average school district plus one student in a given category and the total spending for the average school district. Standard errors clustered at the school district level. All dollar values in adjusted for inflation using the GDP S&L price deflator to constant 2025 dollars. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Estimated Additional Per Pupil Expenditures by Disability Category, Heterogeneity by Property Tax Value

	(1) Base	(2) Below Median Income Districts	(3) Above Median Income Districts
Cognitive Impairment	$14,947^{***}$	$15,746^{***}$	$14,280^{***}$
	(2,982)	(2,761)	(3,549)
Emotional Impairment	$20,205^{***}$	$18,863^{***}$	$21,735^{***}$
	(3,205)	(3,341)	(3,593)
Speech and Language Impairment	$4,492^{***}$	$4,414^{***}$	$4,610^{***}$
	(1,271)	(1,211)	(1,530)
Specific Learning Disability	$1,998^{**}$	$1,939^{**}$	$2,074^{*}$
	(956)	(869)	(1,186)
Autism Spectrum Disorder	$22,263^{***}$	$21,216^{***}$	$23,516^{***}$
	(2,912)	(2,824)	(3,296)
Other Health Impairment	$12,129^{***}$	$11,098^{***}$	$13,275^{***}$
	(1,901)	(2,064)	(2,086)
Other Severe Disability	$23,978^{***}$	$21,976^{***}$	$26,207^{***}$
	(3,500)	(3,487)	(3,808)

Notes: Estimated 1-student expenditure differentials from the fully specified model in Equation (1) estimated via a stochastic frontier model. Estimates represent total additional expenditures above those for a student without a disability. Sample includes all Michigan school districts with non-missing covariates between 2011-12 and 2024-25, excluding 2019-20 due to lack of test score data. Columns (2) and (3) provide estimates of expected expenditure changes separately for low income and high-income school districts defined by the proportion of economically disadvantaged students in the district. Dollar values represent the difference between the total spending for the average school district plus one student in a given category and the total spending for the average school district. Standard errors clustered at the school district level. All dollar values in adjusted for inflation using the GDP S&L price deflator to constant 2025 dollars. Standard errors clustered at the school district-level and calculated via the delta method for transformation, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

9 Appendix 2: Cost Function Framework and Methods

This appendix provides more details on the derivation of the cost function framework in education, the functional form of Equation (1) in the paper, and empirics of the estimation. The "cost" of education represents the minimum spending required to reach a specified level of student achievement or other educational output (Imazeki & Reschovsky, 2005). A cost function approach aims to estimate these costs in a general quantitative framework of the following form:

$$Expenditures = f(InputPrices, Outcomes, StuChars, efficiency) \tag{2}$$

In this construction, school district expenditures are modeled as a function of the prices of school inputs faced by each school district, student achievement, the characteristics of the student population, and the efficiency of the school district (Downes & Pogue, 1994; Duncombe & Yinger, 2005; Imazeki & Reschovsky, 2005). Theoretically, the relationships between these factors and school expenditures are assumed to be positive, although they could be negative if school districts find returns to scale as well (Gronberg et al., 2015).

Once estimated, the relationships between each of input prices, outcomes, student characteristics provide direct estimates of the additional expenditures needed to achieve any level of educational output as well as the additional resources needed to support students to meet this standard (Duncombe et al., 2015). For example, Gronberg et al. (2005) find that a low-income student is between 28% more expensive to serve relative to a student who is not low-income. This immediately translates into an additional per-pupil weight to support low-income students. As a result, estimates from cost functions have increasingly been used to define pupil weights in state funding formulas for education (Duncombe & Yinger, 2005, 2011; Grosskopf et al., 2017).

To understand the relationship between student achievement, teacher salaries, student demographics, and school district spending, I estimate ordinary least squares and stochastic frontier models following Gronberg et al. (2005), Imazeki (2008), Gronberg et al. (2011), Gronberg et al. (2015), Taylor et al. (2023). My generic cost model takes the following form:

$$C = C(InputPrices, Outcomes, Stucars|\beta) \times \exp(v + u) \tag{3}$$

In this model, costs C are defined as a function of input prices (teacher salaries), outcomes (student achievement) and environmental factors (student characteristics). β represents a vector of the coefficients describing how each of the inputs, outputs, and environmental factors influence the cost, and the exponential error term is modeled as a function of a random, normally distributed shock v plus a half-normally distributed variable u representing school district-level inefficiency. Theoretically, costs cannot be negative, and so the strictly positive exponential error term ensures that the random shock scales costs above or below the true production cost. For any v greater than 0, a firm may have higher costs due to external factors such as weather, illness, or holidays, for example. Similarly, for any u greater than 0 (or a non-zero level of inefficiency), the exponential error term increases and overall costs increase as well.

This theoretical model constrains my estimation strategy in two ways. First, to convert the model to a more standard additive equation, I take the log of my dependent variable (average per-pupil expenditures). Assuming that input prices, outputs, and environmental factors interact multiplicatively to produce costs, this changes the multiplicative exponential error to an additive error term of the following form:

$$\begin{aligned} \ln(C) &= \ln(C(InputPrices, Outputs, Environment|\boldsymbol{\beta}) + v + u \\ &= \ln(InputPrices_1^{\beta} \times Outputs^{\beta 2} \times Environment^{\beta_3} + v + u \\ &= \beta_1 \ln(InputPrices) + \beta_2 \ln(Output) + \beta_3 \ln(Environment) + v + u \end{aligned} \tag{4}$$

This theoretical cost function then gives rise to an estimable model of education costs. This is a standard Cobb-Douglas model of production (Goldberger, 1968). Second, given the normal and half-normal error terms, I estimate this stochastic frontier model by maximum likelihood (Aigner et al., 1977; Belotti et al., 2013; Greene, 1993).

9.1 Functional Form

While the model in Equation (4) is both theoretically grounded and parsimonious, substantial research has identified non-linear relationships between school district characteristics and spending. For example, Gronberg et al. (2011) and Gronberg et al. (2015) both report school district returns to scale from increasing student enrollment, and as a result, they incorporate both a quadratic and cubic versions of student enrollment in their educational cost models.

To account for potential non-linear relationships between these variables and expenditures, I also estimate a modified translog specification including squares and interactions of all variables in the theoretical cost model in Equation (4):

$$
\begin{aligned}
\ln(PerPupilSpedExp_{it}) = \beta_0 &+ \beta_1 \ln(Salaries_{it}) + \beta_2 \ln(Salaries_{it})^2 + \beta_3 Achieve_{it} \\
&+ \beta_4 Achieve_{it}^2 + \beta_5 \ln(Enroll_{it}) + \beta_6 \ln(Enroll_{it})^2 \\
&+ \sum_j \gamma_j x_j + \sum_j \theta_j x_j^2 + \mathbf{\Omega X}_{it} + v_{it} + u_{it}
\end{aligned} \tag{5}
$$

For each school district i and school year t, $PerPupilSpedExp$ represents per pupil special education expenditures, Salaries represents average teacher salaries, Achieve represents average student achievement measured in standard deviations, Enroll represents the total headcount enrollment in a school district, and x_j represents one of the proportion of students economically disadvantaged, classified as English learners, or identified with a particular disability. The square of each of these variables appears in this model, and **X** represents a matrix of interactions of all variables as well. Following prior research, I also include I include the cubic term for the log of student enrollment following (Gronberg et al., 2015). Notably, this model is modified in that all proportional variables appear untransformed as these variables may be equal to 0.

This version of the model is extremely flexible. Including all covariates, squares, and interactions allows for substantial non-linearity, and taking the log of per-pupil operating expenditures allows these additional terms to be added linearly. Estimating this model using a stochastic frontier further allows for direct estimation of the inefficiency parameter u via a maximum likelihood approach.

9.2 Panel Models

Regarding the panel data models with fixed effects in Appendix Table A4, I estimate all models with fixed effects by including dummy variables for each school district, and I compute predictions from this model. Considering the stochastic frontier model, this differs from a "true fixed effects" stochastic frontier model as this would incorporate both unit dummies and a unit-specific inefficiency term (Greene, 1993). Given my goal to estimate the difference in predictions of this model, estimating the technical inefficiency separately for each district complicates the predictions as inefficiency becomes a central part of the prediction. This creates a different challenge as these predictions may be highly imprecise given a small level of estimated inefficiency. To avoid this and to avoid bootstrapping standard errors of the predictions, I only incorporate district-level fixed effects instead (Belotti et al., 2013).