Real Needs and Real Resources: Identifying Indicators of School Funding Equity

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The National Academy of Science has asked me to address three questions. First, what would it cost to narrow achievement gaps for disadvantaged students? Second, assuming that those funds became available, what does the literature tell us about how the money should be spent? And finally, what indicators could be used to measure progress toward closing the gaps? I address each in turn.

What Would It Cost to Narrow Achievement Gaps for Disadvantaged Students?

The school funding and finance literature has identified three main drivers of educational cost: student needs, input prices, and economies of scale. Each of these factors can influence the funding needed to help narrow the achievement gap for disadvantaged students. Therefore, each has been the subject of considerable researResearch on student needs. Researchers have identified a number of student characteristics that are associated with greater resource needs. Commonly researched student characteristics include socioeconomic status (e.g., Duncombe and Yinger, 2005a), English proficiency (e.g., Gandara and Rumberger, 2008) and special education status (e.g., Gronberg et al., 2011). There is little doubt among researchers that school districts with large numbers of students in each of these categories are more costly to operate than other districts.

The open question is: how much more costly? To answer this question, many researchers turn to cost function or production function analyses. An educational cost function is an estimated relationship between educational expenditures (the dependent variable), educational outcomes (one or more endogenous independent variables); input prices; and indicators of the educational environment (such as the share of economically disadvantaged students or the share of English language learners).[1] An educational production function is an estimated relationship between an educational outcome (the dependent variable); real educational inputs (one or more potentially endogenous independent variables); and indicators of the educational environment.[2] Using either a cost or production function, one can predict the cost of achieving a designated outcome level in a district, compare it to the predicted cost of achieving the same outcome level in the same district assuming that there were no economically disadvantaged students, and thereby estimate the additional funding required by the presence of economically disadvantaged students in that district (Reschovsky and Imazeki, 1998 and Duncombe and Yinger 2005a). A similar approach can be used to estimate the additional funding required by the present of English language learners, special education students or any other demographic of interest.

Other researchers turn to cost calculations based on model schools and prototypes. In one version of this approach, researchers draw on the literature to design a school they believe will serve the needs of a baseline population, and similarly design a school they believe will serve a more disadvantaged student body (e.g. Odden, Goetz and Picus, 2008). They then follow an "ingredients method" to calculate the cost of operating their model schools and districts.[3] Differences in the cost of each prototype are interpreted as the additional funding required by disadvantaged populations. In another version of this approach, researchers follow the same basic procedure, except they assemble focus groups of educational practitioners and task them with designing the model schools (e.g. Chambers, Levin and Parrish, 2006).

[1] For more on educational cost functions, see Gronberg, Jansen and Taylor (2011); Taylor, Gronberg and Jansen (2017); Duncombe and Yinger (2005a) or Duncombe, Nguyen-Huong, and Yinger (2015).
[2] For more on educational production functions, see Harris (2010) or Krueger (1999).
[3] The ingredients method basically involves calculating the purchase price of all the real resources associated with an educational program. For example, if the program requires five teachers at a price of $30,000 per teacher and two aides at a price of $10,000 per aide, then the program cost would be 5*30,000+ 2*10,000=$170,000. For more on the ingredients method, which is sometimes referred to as resource cost modeling, see Levin (1975, 2001) or Chambers (1999).

The following sections discuss the research findings regarding funding requirements for the three student demographics most commonly identified as drivers of real resource need: poverty, English proficiency and special education status.

Poverty. Much of the work relating student poverty to educational outcomes has focused on documenting the size of achievement gaps (e.g., Sarin 2005) or demonstrating that the marginal effect of an intervention is greater for low income students than for less disadvantaged students. For example, Krueger (1999) reanalyzed Tennessee's Project STAR, a randomized control trial in which the treatment variable was class size, and determined that low income students benefitted more from class size reductions than did other students. Angrist and Lavy (1999) reached a similar conclusion in their quasi-experimental (i.e. regression discontinuity) analysis of class size in the Israeli context.

A smaller set of researchers have explicitly explored the funding needed to close gaps in educational outcomes. Some have focused on gaps in educational attainment. For example, Jackson, Johnson and Persico (2015) used a difference-in-differences approach to examine the relationship between educational attainment (i.e. years of schooling completed) and school district funding in the United States. They found that "the estimated effect of a 21.7% increase in per pupil spending throughout all 12 school-age years for low-income children is large enough to eliminate the educational attainment gap between children from low-income and nonpoor families" (Jackson, Johnson and Persico 2015, p192).

Other researchers have focused on academic achievement gaps, using correlational or instrumental variables analyses to estimate the additional funding needed to achieve the same level of academic performance with economically disadvantaged students as with students who are not disadvantaged. Recent reviews of the literature include Golebiewski (2011), Rumberger and Gandara (2008) and Baker, Taylor and Vedlitz (2008). All found that the estimated costs of closing achievement gaps varied widely. Some of the studies they surveyed found that no additional funding would be needed (Downes and

Pogue 1994) while other studies suggested that economically disadvantaged students require more than twice the funding of students who are not disadvantaged (Duncombe and Yinger 2005a). As a general rule, the highest cost estimates come from analyses of New York and the lowest cost estimates come from analyses of more rural states such as Arkansas, Arizona, Kansas and Texas.

Which makes sense, given the problematic ways that school finance researchers measure poverty. School finance scholars seldom have access to data on actual student incomes. Instead, they are forced to rely on data about whether or not students participate in the National School Lunch program, or on poverty rates from the US Census Bureau's small area income and poverty estimates (SAIPE) program. Both of those sources measure poverty based on whether or not a student's family income is above or below a poverty line that does not vary geographically (see Baker et al. 2013). In 2017, the poverty level income for a family of three (one adult and two children) living in New York City, where the fair market rent for a two bedroom apartment was $1,637, was $1,642 per month, which was identical to the poverty line for families living in rural Arkansas, where the fair market rent for a two bedroom apartment was only $611.[4] As a result, the standard of living for children identified as living in poverty in New York City was dramatically lower than the standard of living for children identified as living in poverty in rural Arkansas. If standards of living were used to identify poverty rather than income levels, then the estimated poverty rate would be systematically higher in areas with a high cost of living, and systematically lower in areas with a relatively low cost of living (Baker et al. 2013). It is not surprising that estimates of the additional funding needed to serve an economically disadvantaged student body are higher for New York than for Arkansas or Arizona, since the economically disadvantaged identifier means something different in each state, and students so identified in New York are arguably more profoundly disadvantaged than students so identified in other states.

[4] Data on fair market rents from the US Department of Housing and Urban Development (2017).

English proficiency. Many researchers have also estimated the additional funding needed to achieve the same level of performance with English language learners (ELL) as with students who are already proficient in English. Recent reviews of the literature include Jimenez-Castellanos and Topper (2012), Golebiewski (2011) and Rumberger and Gandara (2008). They all found that the estimated range of costs is even wider for ELL students than for economically disadvantage students. For example, Duncombe and Yinger (2005b) estimated that the cost of serving an ELL student in Kansas was a statistically significant, but tiny, 0.14 percent higher than the cost of serving a student who was not ELL. At the other end of the spectrum, Duncombe and Yinger (1997) estimated that the cost of serving an ELL student in New York was four times the cost of serving a student who was not ELL.

Again, there are serious measurement problems with the literature on the cost of serving ELL students. First, there is a problematic feedback loop between academic performance and ELL status that can bias the analyses. Many researchers measure academic performance with passing rates on standardized tests in reading or English language arts, but many states base ELL status on whether or not a student has passed such tests. As a result, it is possible that ELL percentages are lower in districts where students pass the test rather than that tests are lower (and costs therefore higher) in districts where there are more ELL students. Taylor et al (2014) and Taylor, Gronberg and Jansen (2017) dealt with this issue by estimating the cost of serving students who have ever been identified as ELL, rather than those who were currently ELL. They found that in Texas the cost of serving a student who had ever been identified as ELL was between 9 percent and 13.5 percent higher than the cost of serving a student who had never been identified as ELL.

Second, there are important heterogeneities among ELL students. A student who is ELL at the high school level is likely to have greater needs than a student who is ELL in kindergarten. Furthermore, states where nearly all of the ELL student share a common language (like Texas) might be able to exploit economies of scale unavailable in states where there is more language diversity, thereby experiencing lower costs. Imazeki (2008) found in her analysis of California that the marginal cost of serving ELL student who were not Spanish speakers was four times greater than the marginal cost of serving Spanish-speaking ELL students.

More generally, a lack of economies of scale could make it more costly per student to provide bilingual education in some states or districts. A number of researchers, including Downes and Pogue (1994), Imazeki and Reschovsky (2004, 2006) and Gronberg et al. (2015) have found significant nonlinearities in the cost of serving ELL students.

Special education status. A large literature has developed regarding the cost of serving special education students. Recent reviews of the literature include Golebiewski (2011) who notes that there is little consensus as to how to measure the extent of student disabilities, and even less consensus regarding the associated costs. A number of researchers have found that costs were systematically higher for students with more profound disabilities. For example, Gronberg et al (2004) and Imazeki and Reschovsky (2004) found that the cost of serving students with speech and learning disabilities were much lower than the costs of serving other special education students although they were still significantly higher than the costs of serving students in regular education programs.

Research on input prices. School districts don't use money to produce educational outcomes; they use real educational resources like teachers, administrators, textbooks and software. And the prices that districts must pay to acquire the real resources they need differ from district to district and state to state. Therefore, differences in input prices—particularly differences in the price of labor—drive differences in the funding needed to close achievement gaps.

Labor is the most important price difference, not only because schools are such labor intensive enterprises, but also because wages are the price most likely to differ from district to district. Differences in the cost of living and the general attractiveness of communities lead to significant, regional differences in the prices school districts must pay teachers, administrators, support staff and other school district personnel (Taylor 2015). Districts in urban areas must pay more than other districts to compensate for the higher cost of living and districts in isolated areas may need to pay a premium to compensate for the lack of local amenities.

A number of researchers have documented large geographic differences in the cost of hiring educators (e.g. Chambers 1996, Stoddard 2005, Goldhaber 1999, Taylor and Fowler 2006, Taylor 2006, or Rothstein and Smith 1997) and a number of methodologies have arisen to quantify those differences (Taylor 2015). Regardless of the methodology, researchers consistently find that wage levels are higher in urban areas, especially those in California and New England. Which is important because as Baker et al. (2013) discuss, large urban school districts—where labor costs tend to be higher—serve a disproportionate number of disadvantaged students.

Furthermore, differences in working conditions can also lead to differences in the prices required to attract and retain high quality teachers. Theory suggests that differences in working conditions manifest as either higher salaries to compensate for the relative unattractiveness of the position, or lower retention rates. Researchers have found both types of evidence to suggest that teachers perceive working conditions as less desirable in schools with higher proportions of disadvantaged students. For example, Goldhaber, Destler, and Player (2010) found that teachers commanded a salary premium from schools with more “challenging student populations”. Clotfelter, Glennie, Ladd, and Vigdor (2008) examined a North Carolina policy experiment in which math, science and special education teachers were awarded an annual bonus for serving in secondary schools with either high poverty rates or low test scores, and found that differential pay sharply reduced teacher turnover in those schools. Hanushek, Rivkin and Kain (2004) examined patterns of teacher mobility and concluded that teachers strongly preferred schools with fewer low income, low performing or minority students. They concluded that large salary increments would be required to reduce turnover rates in a large urban school district to suburban-school levels.

Research on economies of scale.

Andrews, Duncombe and Yinger (2002) surveyed 10 cost studies that were published between 1985 and 1999, and concluded that per-pupil cost was very high for school districts with fewer than 500 students, lowest for school districts in the 2,000 to 5,000 student range, and somewhat higher for school districts with more than 5,000 students.

More recent cost-function analyses have reached similar conclusions about the high cost of operating small districts, but offer contradictory findings about the least-cost district configuration. For example, Imazeki and Reschovsky (2006) found that most of the savings from economies of scale were realized by the time the district reaches 10,000 students, but that costs continued to decline with size until enrollments reached approximately 85,000. Gronberg, Jansen, and Taylor (2011) and Eom et al. (2016) found that costs continued to decline with size for even the largest districts. Taylor, Gronberg and Jansen (2017) found evidence that the most important economies of scale arise at the school rather than the district level, suggesting that increases in district size only reduce costs if they are accompanied by increases in school size.

Thus, there is a consensus in the literature that small school districts are much more expensive to operate than midsized or larger school districts. There is much less agreement in the literature about whether or not very large districts (such as Los Angeles Unified or Houston Independent School District) suffer from diseconomies of scale. Regardless, the evidence strongly suggests that the cost of closing the gaps for disadvantaged students will depend on the size of the districts in which they are enrolled.

How Should and Shouldn't the Money Be Spent?

The demonstrated differences in the cost of education raise an obvious question: how should funds be spent to narrow the achievement gap most effectively. There are no silver bullets, but the literature has coalesced around a few key ideas.

High Quality Preschool.

Investments in the education of young children can have strikingly large returns, particularly for students who are economically disadvantaged or ELL. For example, Heckman et al. (2010) evaluated the HighScope Perry Preschool Program, a resource intensive, early intervention program targeted toward disadvantaged African-American youth. They found that previous scholars had overstated the return on investment because they had ignored flaws in the randomization protocol, but that even after correcting for those flaws, the return on investment in preschool was statistically significant and exceeded the historical return on non-educational investments. Temple and Reynolds (2007) evaluated the Perry Preschool program as well as two other high quality programs—the Chicago Child-Parent Centers (CPC) and the Carolina Abecedarian Project—and reached similar conclusions. Many of the outcomes contributing to the positive evaluation of these programs are nonacademic (such as reduced arrest and incarceration rates) but participants also had lower rates of special education placement, reductions in grade retention, and higher levels of educational attainment (Temple and Reynolds 2007; Barnett and Masse 2007).

Not all preschool programs are equally high in quality, and it may be difficult to scale up the intensive interventions provided by the Perry Preschool, Chicago CPC and Abecedarian programs. Therefore, researchers have also focused attention on a large, national program that has provided pre-school for low income children since 1965—Head Start. As a general rule, Head Start programs are of higher quality than the child care otherwise available for low income children (Blau and Currie 2006) but they do not encompass the full suite of interventions provided by the Perry Preschool, Chicago CPC or Abecedarian programs.

The most persuasive evidence on the effectiveness of Head Start is generally positive. Currie and Thomas (1999) found that it was important to control for selection into the program, but that children who were in Head Start outperformed their siblings who were not in the program. Ludwig and Miller (2007) exploited a large and lasting discontinuity in Head Start funding to examine the program's effects on child mortality rates and academic outcomes using a regression discontinuity research design. They found that higher levels of educational attainment and sharply lower child mortality rates could be associated with the Head Start program, but found only weak evidence of any programmatic impacts on academic achievement. Puma et al. (2010) evaluated a randomized control trial (RCT) based on a nationally representative sample of Head Start programs, and concluded that the program had positive impacts on children's school readiness, but that most of those benefits did not persist to the end of first grade. "[B]y the end of 1st grade, there were few significant differences between the Head Start group as a whole and the control group as a whole for either cohort." (Puma et al. 2010, pp xxxvii). Bitler, Hoynes and Domina (2014) dug deeper into the data from the Head Start RCT and found consistent results regarding fade out, but some evidence that cognitive gains persisted through first grade for some Spanish speakers. Chor (2016) also evaluated the data from the Head Start RCT and found that Head Start had large and persistent impacts on the mathematics performance of children who were the second generation to participate in Head Start (i.e., those whose mothers had also participated in Head Start). Johnson and Jackson (2017) used difference-in-difference instrumental variables and sibling-difference estimates to demonstrate that "[t]he benefits of Head Start spending were larger when followed by access to better-funded public K12 schools, and the increases in K12 spending were more efficacious for poor children who were exposed to higher levels of Head Start spending during their preschool years." (Johnson and Jackson 2017, p. 1).

Although not all of the evidence is equally supportive, the preponderance of the evidence suggests that increasing the participation of disadvantaged students in Head Start or higher quality preschool programs would reasonably be expected to help close the gaps for disadvantaged children.

High Quality Teachers

Research demonstrates that teacher quality matters enormously, especially for disadvantaged students.[5] For example, Hanushek (2009) estimated that the average achievement gap between an economically disadvantaged student and a student who is not economically disadvantaged could be closed entirely if the student had a good teacher (as opposed to an average teacher) for 4-5 years in a row. Replacing below average teachers with above average teachers would close the gap even faster.

Unfortunately, the teacher characteristics most likely to drive teacher salaries—years of experience and advanced degrees are poor indicators of teacher quality.

There is almost no evidence that advanced degrees make teachers more effective in the classroom. Hanushek and Rivkin (2006) examined 170 research estimates of the relationship between student performance and teacher educational attainment. Only 9% of the 170 estimates reported a significant, positive effect of any sort. Among value-added estimates of student performance (which are generally considered higher quality evidence) there were no studies indicating that teachers with advanced degrees were generally more effective in the classroom. However, a few studies have found that teachers with advanced training in mathematics were more effective at teaching mathematics (e.g. Goldhaber and Brewer 2000).

The evidence on teacher experience is almost as discouraging. Beginning teachers tend to underperform more experienced ones but the learning curve is steep. For example, Rivkin, Hanushek and Kain (2005) found that teacher experience was significantly related to student achievement but only for beginning

[5] For a review of the literature on teacher quality, see Pelayo and Brewer (2010).

teachers. They found no relationship between teacher experience and student achievement following the initial years in the profession. Rockoff (2004) also found significant gains over the first few years of experience and generally negligible improvements thereafter.[6] Harris and Sass (2011) found that experience enhanced the productivity of elementary and middle school teachers, but reduced the productivity of high school teachers.

Recent evidence suggest that there is also little difference between traditionally certified teachers and alternatively certified teachers.[7] For example, Henry et al. (2014) found no difference in classroom effectiveness between traditionally certified beginning teachers and alternatively certified beginning teachers at the elementary or middle school levels, but some evidence that alternatively certified teachers who were not part of Teach for America (TFA) were less effective than traditionally certified teachers in high school math and science. In contrast, TFA teachers equaled or outperformed traditionally certified beginning teachers in all of the grade levels and subject matters they evaluated. Chiang, Clark and McConnell (2016) found that TFA teachers were more effective than more experienced non-TFA teachers in the same school, but Clark et al. (2015) found that TFA teachers were no more or less effective than other novice teachers.

Thus, while investments in teacher quality would be a very good idea, there is no evidence that across the board increases in teacher pay—which would just perpetuate the existing linkage between money and meaningless teacher credentials—would be a good policy recommendation. Rather, the NAS should consider supporting more innovative compensation strategies, such as incentive pay or differential pay

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[6] Rockoff (2004) examine four measures of student performance: math computation, math concepts, reading comprehension and vocabulary. He found a positive and persistent relationship between teacher experience and reading comprehension, but no gains in student performance beyond the first two years of teacher experience for vocabulary or either measure of mathematics.

[7] For a review of earlier work, which does suggest positive effects of certification, see Boyd, Lankford and Wycoff (2008)

for teachers in hard-to-staff schools or subject areas.[8] Research suggest that we have much to learn about the design of optimal incentive pay plans (Springer and Taylor, 2016), but that such plans can be associated with large gains in student performance (e.g., Lavy 2002; Muralidharan and Sundararaman, 2011; or Imberman and Lovenheim, 2015).

Smaller Class Sizes

The most persuasive evidence on class size comes from Tennessee's Project STAR experiment, and indicates that relatively large reductions in class size (from 22-25 student classrooms down to 13-17 student classrooms) can have relatively large effects, especially for low income students and minority students (Schanzenbach 2010; Krueger, 1999; Chetty et al. 2011). However, a greater than 30% reduction in class size (as in Project STAR) would also be a very expensive intervention. A large expansion in the number of classrooms would typically require the construction of new facilities and the hiring of many additional teachers.

California provided a test case. A 1996 class size reduction program in California emulated the Project STAR experiment and reduced class sizes throughout the state by roughly ten students per class (Jepson and Rivkin, 2009). It cost the state more than $1 billion per year, and generated 25,000 new teaching positions—many of which were filled by beginning teachers. Jepson and Rivkin (2009) evaluated the program and found that smaller classes had a modest impact on math and reading achievement (0.1 and 0.06 standard deviations, respectively), all other things being equal, but that the negative impact of having a beginning teacher was nearly equal in magnitude to the positive benefit of smaller classes. Over time, the new cohort of teachers gained experience, so the offsetting effect on teacher quality was probably temporary. However, it is also clear that the costs of class size reduction are much larger than they first appear.

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[8] For more on differentiated compensation for hard-to-staff schools, see Clotfelter, Glennie, Ladd, and Vigdor (2008) or Strunk and Zeehandelaar (2011).

Other researchers have compared the rate of return on various interventions to the rate of return on class size reduction, and class size reduction is consistently outmatched. For example, Temple and Reynolds concluded that the “positive economic returns of high-quality preschool programs exceed most other educational interventions, especially those that begin during the school-age years such as reduced class sizes in the elementary grades.“ (Temple and Reynolds, 2007, p.). Rivkin, Hanushek and Kain (2005) concluded that a one standard deviation improvement in teacher quality would produce larger benefits than a ten student reduction in class size.

Thus, while the evidence suggests that large reductions in class size could be effective at reducing the achievement gaps for disadvantaged students, they are unlikely to be cost effective.

What Key Indicators Could Be Used to Measure Progress Toward Closing the Gaps?

My review of the literature suggests three key areas where NAS could develop indicators of progress toward equity.

Improved Measures of Poverty at the School and District Levels.

The official poverty statistics under-identify need in some areas and over-identify it in others. This is clearly a first-order problem that must be addressed. Measurement error in the poverty statistics limits our ability to measure achievement gaps and to respond with appropriate treatments. These biased metrics also drive significant amounts of state and local compensatory aid to school districts, thereby misallocating scarce educational resources.[9] When state and federal programs target resources based on a biased measure of need, it is not surprising that gaps persist.

[9] As discussed in Taylor and Dar (2014), in 2013 Title I of the Elementary and Secondary Education Act allocated more than $13.7 billion to U.S. school districts based on the percentage of students from families at or below 100% of the federal poverty level (FPL). In addition, the National School Lunch Program provided free lunches to students from families with incomes at or below 130% of FPL, and reduced price lunches to students from families with incomes between 130% and 185% of FPL (Taylor and Dar 2014). Many states also used free lunch status as a driver of compensatory funding in their school funding formulas (Taylor 2015).

Many researchers have developed alternative poverty indices (e.g., Baker et al. 2013; Renwick 2009; Chung, Isaacs and Smeeding, 2013; or Meyer and Sullivan, 2012). One such measure is the Supplemental Poverty Measure (SPM). Based on recommendations issued by the National Academy of Science fifteen years earlier, the SPM was developed by the Obama administration in 2010 as a complementary statistic to improve the understanding of economic circumstances of individuals (Short 2013). The SPM redefines poverty as the lack of economic resources for consumption of basic needs such as food, housing, clothing, and utilities. To determine family resources, gross money income is supplemented with benefits such as food stamps, housing subsidies, and tax credits, while adjustments are made for out-of-pocket expenses like health insurance premiums, payroll taxes and child care costs. Crucially, the SPM also adjusts the poverty thresholds for regional differences in housing costs. Although the SPM does not fully reflect differences in living standards because it does not capture amenity differences, it represents a much improved measure of student poverty.

The SPM has been available nationally and at the state level since 2011 (Fox, 2017) and SPM thresholds are available by metropolitan areas.[10] The NAS should advocate for the annual production of the SPM at the school district level. In the meantime, the NAS could use the approach in Baker et al. (2013) to translate metro-level estimates of the SPM into district-level estimates.

I recommend that the NAS also advocate for better targeting of Title I and National School Lunch program funding. A simple indicator variable for funding equity would be whether or not eligibility for Title I or the School Lunch Program was still determined by a nationwide poverty threshold.

State-by-State Measures of Real Spending Progressivity. Despite lingering disagreements as to magnitude, the school finance and funding literature has reached a consensus that it costs more—in real terms—to serve students who are economically disadvantaged, ELL or special education. Therefore, a

[10] https://www.census.gov/library/publications/2017/demo/p60-261.html

key indicator of funding equity is whether or not there is a positive correlation between real educational spending and each of these student demographics.

One could modify Baker et al. (2017) to construct such an indicator. On a state-by-state basis, I recommend estimating an expenditure education in which the dependent variables is the natural log of real operating expenditures per pupil and the independent variables are two indicators for school district size (the log of enrollment and the log of enrollment squared) and the percentages of economically disadvantaged, ELL, and special education students. In this context, real operating expenditures would be constructed by using a labor cost index like the NCES' Comparable Wage Index (Taylor 2006, 2015) to deflate the payroll component of current operating expenditures. Funding equity would require that the marginal effect of each student demographic be positive and significantly different from zero.

As a proof of concept, Table 1 presents the results for just such a regression, using Texas data for the 2015-16 school year. The dependent variable has been deflated using my updated version of the Comparable Wage Index, and the regression has been weighted by the number of students in each district so that the coefficients can be interpreted as representing the experience of the average student in the state. As the table illustrates, the distribution of real operating expenditures in Texas had a statistically significant and positive relationship with the percent economically disadvantaged, percent ELL and the percent special education students. The coefficients indicate, for example, that on average an economically disadvantaged student in Texas received 28.3% more real funding than a student who was not economically disadvantaged, all other things being equal. To ease interpretation, NAS could use each state's model to predict the level of funding for a school with 100% economically disadvantage students and the level of funding for a school with 0% economically disadvantaged students and report the ratio of the two (which would be the exponent of the regression coefficients from the table below).

Table 1: Regression Coefficients from an Analysis of Funding Equity in Texas, 2015-16

Percent Economically Disadvantaged	0.283
	(13.62)**
Percent ELL	0.108
	(2.66)**
Percent Special Education	1.871
	(9.85)**
Log of district enrollment	-0.196
	(9.59)**
Log of district enrollment, squared	0.008
	(7.29)**
Constant	9.945
	(103.58)**
R^2	0.49
N	1,199

Note: t-statistics in parentheses. * p<0.05; ** p<0.01

The National Center for Education Statistics, in cooperation with the U.S. Census Bureau, has developed a new, county-level comparable wage index which should be released shortly. The new ACS-CWI is modeled after the work by Taylor and Fowler (2006) but uses restricted access data from the Census Bureau's American Community Survey and incorporates a number of modeling enhancements. This new index, which should be updated annually, will make it possible to estimate similar regressions for each state using publicly available data from the NCES.

As an intermediate indicator, NAS could consider keeping an up-to-date tally of the weights used in each state's school funding formula and the extent to which those formula explicitly include a geographic cost adjustment. Verstegen (2017) indicates that nearly all US states provide additional funding for ELL students.[11] On the other hand, only 37 states make a deliberate effort in their funding formula to adjust

[11] The five states that indicated no funding for ELLs or did not respond to this section of the survey were Indiana, Mississippi, Montana, Pennsylvania and Rhode Island. Verstegen and Knoeppel (2016) indicates that Montana has a block grant for "extraordinary" special education expenses.

for differences in student poverty (Verstegen and Knoeppel 2016) and only 13 adjust for differences in the purchasing power of school districts (Taylor 2015 and authors' updates).

ESSA requires the development of school-level expenditures data. As those data become available, NAS should also consider developing measures of within-district progressivity. Such indicators could be constructed as above, but using campus-level spending (adjusted for differences in labor costs) as the dependent variable.

Measures of Disadvantaged Students' Exposure to Beginning Teachers

The evidence suggests that beginning teachers are less effective in the classroom, and disadvantaged students are more likely than other students to be assigned a beginning teacher (Boyd, Lankford and Wyckoff, 2008).Therefore, reducing the percentage of beginning teachers in disadvantaged classrooms would be expected to improve the performance of disadvantaged students.

The simplest way to construct an indicator of student exposure to beginning teachers would be to calculate the percentage of disadvantaged students who have a beginning teacher. Ideally, this should be measured at the student level, but data systems in some states may not be up to the task. A reasonable approximation might be to measure the percentage of disadvantaged students with a beginning teacher at the school level, assuming that the distribution of beginning teachers within the school was not correlated with disadvantaged status. While imperfect, such an indicator could be easily constructed from currently available data.

It would also be useful to compare the probability that a disadvantaged student had a beginning teacher to the probability that a student who was not disadvantaged had a beginning teacher. There are more sophisticated ways to make such a comparison, but the most straightforward might be to use the ratio of the percentage beginning teachers for disadvantaged students to the percentage beginning teachers for advantaged students. As this ratio decreased, the probability of closing the gaps would increase.

Measures of Disadvantaged Students' Participation in High Quality Preschool Programs

Given the clear benefits of preschool for disadvantaged students, another key indicator of funding equity would be the extent to which disadvantaged students are able to participate in high quality preschool programs. Unfortunately, data on quality-adjusted enrollments are currently unavailable. Until such data become available, I recommend tracking the preschool enrollment rates for disadvantaged students without any adjustments for program quality. Baker et al. (2017) report, by state, on the participation rates for economically disadvantaged three and four-year olds, relative to the participation rates for students who are not economically disadvantaged. Such a ratio can be misleading because it ranks a state like Connecticut, where 53% of low income students participate in preschool but the participation rate for advantaged students is also high, below a state like West Virginia, where only 33% of low income students participate in preschool. However, their analysis clearly illustrates the feasibility of constructing an index of the percentage enrollment in preschool programs.

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