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Review of Kansas Education Cost Studies – Second Report

Estimating the Costs Associated with Reaching Student Achievement Expectations for Kansas Public Education Students: A Cost Function Approach (by Lori Taylor, Jason Willis, Alex Berg-Jacobson, Karina Jaquet and Ruthie Caparas)

Jesse Levin (AIR)

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Kansas Legislative Coordinating Board
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American Institutes for Research
1000 Thomas Jefferson Street NW, Washington, DC 20007-3835 | 202.403.5000 | TTY 877.334.3499 | **www.air.org**

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1 – Introduction

The debate surrounding school finance in Kansas and specifically the question of how much funding is necessary to allow for the *suitable* provision for the financing of the state's public education system has been and continues to be at the forefront of policy discussion. As mentioned in the first review submitted to the Kansas Legislative Coordinating Council (Levin, 2018), a series of court cases resulted in two previous research efforts to better understand what constitutes a suitable education and how much would it cost to provide this to all students in the state:

1) Calculation of the Cost of a Suitable Education in Kansas in 2000-2001 Using Two Different Analytic Approaches (Augenblick and Myers, Inc., 2002)
2) Elementary and Secondary Education in Kansas: Estimating the Costs of K-12 Education Using Two Approaches (Kansas Legislative Post Audit Division, 2006)

The current report provides a brief discussion of the funding recommendations put forth by the Kansas State Board of Education Department at their June 12, 2016 meeting. In addition, it includes a review of the new third study conducted by economist Dr. Lori Taylor (Texas A&M) and researcher staff at WestEd:

3) Estimating the Costs Associated with Reaching Student Achievement Expectations for Kansas Public Education Students: A Cost Function Approach (Taylor et al., 2018)

The purpose of this report is to provide a review of this new study focusing on the methodology used and corresponding results in order to inform the current discussion surrounding the forthcoming remedy ordered by the Kansas State Supreme Court.

The report is organized as follows. Section 2 provides a short discussion of the 2016 funding recommendations made by the Kansas State Board of Education Department. Section 3 includes a review of the new study performed by Taylor et al. (2018). Section 4 provides a brief comparison of findings from the two cost function studies, Kansas Legislative Post Audit Division (2006) and Taylor et al. (2018).

2 – Review of *Kansas State Board of Education Funding Recommendations for FY 2018 and 2019*

The Kansas State Board of Education developed their annual recommendations in session on July 12, 2016. Among the recommendations approved by the Board were the following:

- Set Base State Aid Per Pupil at $4,650 for FY 2018 with a $500 increase to $5,150 in FY 2019. However, a subsequent vote on special education funding changed the BSAPP recommendation to $4,604 FY18 and $5,090 FY19.
- Fund Special Education at 85 percent of excess cost, but subtract the amount from the BSAPP amount originally approved.
- Increase Parents as Teachers funding by 1,000 children for an additional cost of $460,000 and requested that Children's Initiative Funds be utilized, not federal funds.
- Fund 100 percent of the law for the Teacher Mentor Program for an additional cost of $3 million.
- Fund Professional Development at 50 percent of the law.
- Fund $35,000 each for Agriculture in the Classroom, Communities in Schools and Kansas Association of Conservation and Environmental Education.
- Fund the law for National Board Certification for an additional cost of $47,500.
- Fund the Pre-K Pilot program at the 2009-10 level for an additional cost of $900,000 and request that Children's Initiative Funds be utilized.
- Fund technical education transportation at original level for an additional cost of $800,000.

Unfortunately, there is very little I can say at present about any methodology underlying the recommendations as they pertain to delivering an adequate education. From the video of the proceedings it seems that the policy recommendations were made based on deliberations surrounding what board members felt should be done and had a reasonable chance of being adopted. However, it is unclear whether any of these recommendations had any basis in formal analysis designed to investigate the funding necessary to provide an adequate education. That being said, I did perform a simple, but informative analysis of the first recommendation put forth above.

Table 1 presents a comparison of the 2005 base per-pupil cost to the base per-pupil costs recommended for fiscal years 2018 and 2019 by the Kansas State Board of Education. To make this comparison, it is necessary to put all the per-pupil figures into dollars of a similar year. I have chosen to peg the dollars to 2017 and done so by inflating (multiplying) the 2005 figure ($4,257) to 2017 dollars using an inflation factor of 1.24 yielding a figure of $5,265. I next adjusted the recommended 2018 and 2019 base figures to 2017 dollars by deflating (dividing by) deflation factors of 1.01 and 1.03, respectively.[1] This generated recommended base per-pupil costs in 2017 dollars equal to $4,544 for 2018 and $4,957 for 2019, which equal 86 and 94 percent of the inflated 2017-dollar equivalent of the 2005 base. Therefore, the proposed increases to the Base State Aid Per Pupil for 2018 and 2019 were not high enough to maintain the 2005 base funding level in real terms. That is, it would not be enough to account for the degree to which inflation eroded the value of the dollar since 2005. To maintain the purchasing power of the 2005

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[1] Inflation and deflation rates were derived from the Bureau of Labor Statistics Consumer Price Index for All Urban Consumers (CPI) in the Midwest states (series CUUR0200SA0 available here: https://data.bls.gov/pdq/SurveyOutputServlet?data_tool=dropmap&series_id=CUUR0200SA0,CUUS0200SA0).

Base State Aid Per Pupil the funding levels would have to increase further by $722 in 2018 and $308 in 2019.

Table 1 – Comparison of Base Per-Pupil Cost in 2005 to Recommended Levels for 2018 and 2019

	Base Per-Pupil Cost			
	2005 Base	***2005 Base Inflated to 2017 Dollars***	***Recommended 2018 Base Deflated to 2017 Dollars***	***Recommended 2019 Base Deflated to 2017 Dollars***
Cost Per Pupil	$4,257	$5,265	$4,544	$4,957
Relative Difference from 2005 Base Inflated to 2017 Dollars			86%	94%
Additional Increase in Future Bases to Maintain Real Value of 2005 Base			$722	$308

3 – Estimating the Costs Associated with Reaching Student Achievement Expectations for Kansas Public Education Students: A Cost Function Approach (Taylor et al., 2018)

Study Methodology

Cost Function Approach (Stochastic Cost Frontier)

Similar to the 2006 study by LPA (Kansas Legislative Post Audit Division, 2006), the study by Taylor et al. (2018) employs a cost function methodology. However, unlike the cost function performed as part of the LPA study, the newer study estimates a cost function using a stochastic frontier analysis approach (SFA). SFA finds its origins in the field of economics, where there is a long history of developing models that describe units of output produced (production functions) or the cost of producing output (cost functions).[2] An important development include in these models is that take into account not only the technology of production (i.e., the combinations of inputs used, their prices, and corresponding spending), but also the (in)efficiency with which outcomes are produced.

The stochastic cost frontier model used by Taylor et al. (2018) assumes that there is a set of minimum costs at which different levels of outcomes can be produced given the inputs being used and other environmental cost factors. While schools can at best operate at a minimum cost (with perfect efficiency), they may exceed this due to either 1) random factors that are outside of the control of schools or 2) inefficiency that is at least partially a result of the choices made by schools. In simple mathematical terms, the stochastic cost frontier is specified as a function with deterministic and random components:

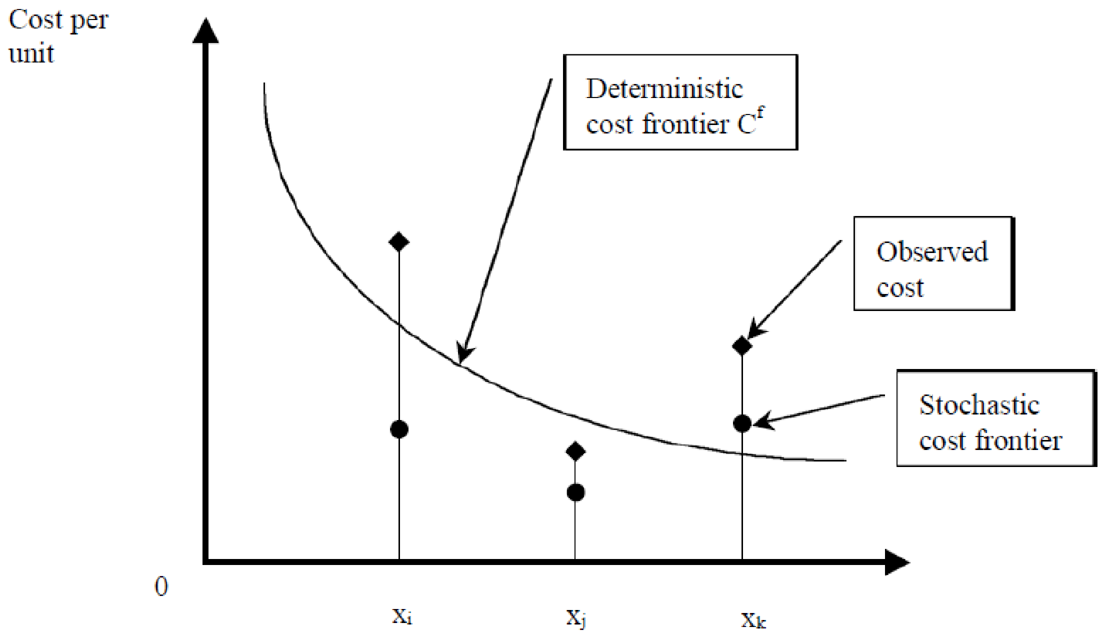
$$\textbf{(1)}\ \ \textbf{Spending} = \textbf{f}(\textbf{Outcomes}, \textbf{Input Prices}, \textbf{Enrollment Size}, \textbf{Environmental Factors}) + \\ \textbf{Random Factors} + \textbf{Inefficiency}$$

The first line in equation (1) is what is called the deterministic portion of the model or the amount of spending that we can determine through relationships between spending and observable factors (i.e., outcomes, quantities of inputs and their prices, enrollment and other environmental factors), while the second line introduces the amount of spending that cannot be explained by the observed factors and is made up of those that are random (stochastic) and any inefficiency due to the choices of the producer (schools).

Exhibit 1 from Anderson and Kabir (2000) provides a simple illustration the component of the stochastic cost frontier model. The graph shows the cost per unit production of a common outcome (y-axis) and the number of students for which the outcome is produced (x-axis). The curved line shows the cost function based solely on the deterministic portion of the model (deterministic cost frontier). The dots show how far above or below the deterministic cost frontier three different schools are spending and represent the random or stochastic component of the model (i.e., this collection of dots represents the stochastic cost frontier).

[2] Among one of the earliest expositions is Farrell (1957).

Exhibit 1 – Graphical Illustration of Estimated Costs in Stochastic Cost Frontier Model



For schools i and j, there seemed to be favorable random conditions that put downward pressure on their costs (i.e., their dots lie below the deterministic cost frontier), while the opposite was true for school k. The diamonds represent the costs that we actually observe for each school. The vertical distance between these observed costs and diamonds represent inefficiency or differences in cost associated with unobservable factors (not controlled for in the deterministic portion of the model) thought to be at least partially caused by the decisions made by schools. For all three schools, the observed costs (diamonds) are higher than those that define the stochastic cost frontier. By definition, the observed costs that may include inefficiency must be larger or equal to the corresponding costs on the stochastic frontier. For school i, the inefficiency is most severe, which offsets the negative random component and pushes the observed cost above the deterministic cost frontier. In school j, the degree of inefficiency is less severe so that the observed cost is still below the deterministic cost frontier. For school k, the inefficiency is relatively moderate and reinforces the upward pressure on costs due to unfavorable random conditions so that the observed cost is pushed even further above the deterministic cost frontier.

Variables Used in Cost Model

Outcomes

The outcomes used in the model are based on proficiency rates on English language arts and math tests (College and Career Ready Assessments) first administered under the Kansas Assessment Program (KAP) in the 2014-15 school year. Particular attention was given to comparing the definitions of proficiency of the old assessment standards in place under the No Child Left Behind (NCLB) law and the new assessment standards under KAP. In general, the old assessment included five categories including Exemplary, Exceeds Standard, Meets Standard, Approaching Standard, and Academic Warning with the first three indicating proficiency, while the new standards range from 4 down to 1 with levels 3 and 4 indicating that a student is proficient (on track to being college and career ready).[3]

The authors next developed two different outcome thresholds to use in their cost projections based on the definitions of proficient under the old and new assessment systems. To do this, they considered the goals set in the state's plan approved by the U.S. Department of Education under the Every Student Succeeds Act (ESSA) to determine what the annual increase in proficiency rate would be to meet the goal of a 75 percent proficiency rate by 2030 and translated this into necessary annual gains. Under the new standards where categories 1 and 2 define proficiency it was determined that ELA and math rates in these two categories would both have to increase annually by about 3.5 percent.[4] Using the old NCLB standards it was determined that ELA and math proficiency rates would be defined by the new KAP categories 2, 3 and 4, and would have to increase annually by 3.6 and 5.4 percent, respectively.[5] To facilitate the use of achievement measures across the different grades (3 through 8 and 10) and subjects (ELA and math) tested, the authors used data on individual students to calculate conditional national curve equivalent (NCE) scores. School-level averages of these individual ELA and math measures represent a school's yearly academic progress.

In addition, the authors included measures of graduation rate based on a cohort method (i.e., the percent of entering students that graduated in a normal time frame). Based on the goal included in the state's ESSA plan, the authors set an annual increase of 0.68 percentage points in order to meet the graduation target of 95 percent set for 2030.

Input Prices

Measures of input price levels included a teacher salary index that was based on a statewide hedonic wage model.[6] Note that the cost model used in the study by the Legislative Division of Post Audit (2006) also included this type of salary index.

Environmental Factors

The environmental factors used in the model included district-level enrollment, school-level incidences of student needs (students eligible for free- or reduced-price lunch, those designated as English learners, and students in special education), the grade-level designation of the school (elementary, middle or high), and a density measure (population per-square mile).

Efficiency Measures

Indirect measures of efficiency were included to account for the fact that schools subject to more competition or in areas with adult populations that are more likely to monitor public spending and hold public institutions accountable will tend to spend more efficiently. To this end, the authors included the following factors as indirect efficiency measures: concentration of enrollment (Herfindahl index) in metro/micropolitan areas, indicator for whether or not the district is located in a metropolitan area that spans state lines, percentage of households in county that are owner-occupants, and the percentages of the county population with at least a bachelor's degree and the percentage of households in which the residents are over age 60.

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[3] See Table 5 in Taylor et al. (2018) for a side-by-side comparison of the old and new assessment standards.
[4] Note, this would yield a target proficiency rate of 60 percent within five years (by the 2021-22 school year).
[5] Note, this would yield a target proficiency rate of 90 percent within five years (by the 2021-22 school year).
[6] For an early example of this type of model see Chambers (1981).

Expenditures

Per-pupil expenditures were based on school-level measures of total operating expenditures that excluded food, transportation, capital outlay for construction, community service, debt service, fund transfers and adult education.

Results

Table 2 contains the estimated stochastic cost frontier model. Almost all the results make intuitive sense.

Table 2 – Estimated Stochastic Cost Frontier Model

Variable	***Estimates***
Normal Curve Equivalent	5.295*** (-0.607)
Graduation Rate	1.244*** (-0.262)
Graduation Rate * High School	0.696*** (-0.0995)
District Enrollment	-1.444*** (-0.0568)
District Enrollment squared	0.0991*** (-0.00378)
Salary index (log)	1.373*** (-0.279)
Rural indicator	0.0505*** (-0.0112)
% Economically Disadvantaged	0.886*** (-0.078)
% English Language Learner	0.226*** (-0.0667)
% Special Education	2.157*** (-0.226)
Population Density	0.166*** (-0.018)
Elementary grades served	-0.129*** (-0.016)
High school grades served	-0.508*** (-0.0909)
% English Language Learner, sq	-0.623*** (-0.109)
% Special Education, sq	-6.135*** (-0.674)
Population density* Salary Index	-0.510*** (-0.0414)
AYP Schoolyear = 2016	-0.0364*** (-0.00591)
First stage Residuals, NCE	-5.102*** (-0.609)
First stage residuals, Graduation	-1.454*** (-0.271)
Herfindahl Index, log	0.797*** (-0.249)
Border metro	2.320*** (-0.372)
% Owner occupied	7.293*** (-1.321)
% Over 60	-2.316 (-1.496)
% College	-12.06*** (-1.542)
Constant	9.644*** (-0.357)
Usigma	-7.214*** (-0.958)
Vsigma	-4.095*** (-0.0418)
Observations	2,310
***** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses.**	

Increases in outcomes cost more; each percentage point increase in the NCE costs approximately 5.3 percent more), while each percentage point increase in graduation rate is associated with a 1.9 percent increase in cost at the high school level and a 1.2 percent increase at the lower grades. Scale of operations as defined by district enrollment shows economies of scale so that costs decrease up to a certain point (more on this below). Costs will be higher for those schools in areas with higher teacher salaries. Those schools in rural areas have higher costs, however, areas which are more population dense also tend to cost more. Cost is positively associated with student needs (incidences of economic disadvantage, English learners and special education), but less so at higher incidences of English learners and special education students. Lack of educational competition (high concentration of education providers in the market) is associated with higher costs (more inefficiency), while the percent of population that is over 60 and college educated (with a BA or higher) is associated with lower costs (less inefficiency). However, the percent of owner-occupied housing tends to increase cost (inefficiency).

Table 3 includes the resulting estimated base per-pupil costs associated with achieving a 95 percent graduation rate (in 2030), as well as indices that adjust funding for: 1) cost factors associated with grade level (calculated in the base per-pupil cost) and regional, scale and student needs cost factors; and, 2) to allow for "compensatory" support of district progress towards desired proficiency rates under the old and new standards.[7] The base per-pupil cost varied from $3,395 to $4,113 with a raw average across districts of $3,766 and a statewide average of $3,727. The regional index ranged from 1.05 to 1.94, with raw and statewide averages of 1.69 and 1.46. The economies of scale index values went from 1.00 to 2.75 with raw and state averages of 1.24 and 1.42, respectively. The student needs index ranged from 1.000 to 1.91 with raw and state averages of 1.35 and 1.39. The compensatory adjustments for the old standards ranged from 0.23 to 2.81 and averaged 1.23 across districts and 1.26 statewide. Finally, the compensatory adjustment indices for the new standards ranged from 0.25 to 2.96 with raw and statewide averages of 1.29 and 1.31, respectively.

The final four columns of the table show both statewide current per-pupil spending in 2016-17 and averages associated with the funding adjustments projected to all districts. The statewide current spending per-pupil was calculated by the authors to be $9,333. Applying the regional, scale and student needs adjustments to the base yields a per-pupil cost that ranges from $5,199 to $28,094, with a raw average across districts of $10,574 and statewide weighted average of $10,433. Also including funding adjustments that would allow all districts to achieve adequacy as defined by the old standards (an average of 90 percent of students scoring in KAP categories 2, 3 or 4 on the ELA/math assessments) would cost between $4,940 and $38,405 per pupil, $12,964 on average across districts, and an average of $13,204 statewide. Finally, using the new standards (an average of 60 percent of students scoring in KAP categories 3 or 4 on the ELA/math assessments) would cost between $5,303 and $40,455, with district-level and statewide averages of $13,620 and $13,767, respectively.

[7] Using the old state standard, the proficiency threshold defined by the authors is average of 90 percent of students scoring in KAP categories 2, 3 and 4 on the ELA and math assessments, while the new state standards for proficiency dictate that there would be an average of 60 percent of students in KAP categories 3 and 4 on the two assessments.

Table 3 – Average, Minimum and Maximum of Cost Indices and Per-Pupil Costs for Kansas Districts (2016-17)

					Compensatory		*Current Spending and Adequate Per-Pupil Costs*			
	Base Per-Pupil Cost (95% Graduation)	***Regional Index***	***Economies of Scale Index***	***Student Needs Index***	***Old Standards***	***New Standards***	***Current Per-Pupil Spending (2016-17)***	***Projected Per-Pupil Costs - Regional, Scale and Needs Adjustments Only***	***Adequacy Per-Pupil Costs - Old Standards***	***Adequacy Per-Pupil Costs - New Standards***
Raw Average	$3,766	1.69	1.24	1.35	1.23	1.29		$10,574	$12,964	$13,620
Weighted Average	$3,727	1.46	1.42	1.39	1.26	1.31	$9,313	$10,433	$13,204	$13,767
Minimum	$3,395	1.05	1.00	1.00	0.23	0.25		$5,199	$4,940	$5,303
Maximum	$4,113	1.94	2.75	1.91	2.81	2.96		$28,094	$38,405	$40,455
Projected adequate per-pupil costs calculated by reviewer.										

Using the figures upon which Table 3 is based (Technical Appendix E), the authors derive aggregate statewide cost figures that show current (2016-17) per-pupil spending to be $9,313 (Table 4). Accounting for the differential effects of the cost factors would require a per-pupil cost of $10,419 or $5.103 billion statewide (a 9.7 percent increase over current spending). Under Scenario A, which assumes the old standards (average of 90 percent of students at KAP levels 2, 3 or 4 in ELA/math) the per-pupil and statewide costs increase to $13,144 and $6.438 billion, respectively (a 38.4 percent increase). Under the new standards (average of 60 percent of students at KAP levels 3 or 4 in ELA/math) the per-pupil and statewide costs would increase to $13,717 and $6.719 billion, respectively (a 44.4 percent increase).

Table 4 – Overall Necessary Investment in Statewide Spending to Support Educational Adequacy in 2016

	Cost Estimate ($)	***Absolute Increase Over Current***	***Relative Increase Over Current***	***Per Pupil Cost Estimate ($)***
Current K-12 Spending	$4.652 billion	n/a	n/a	$9,313
No compensatory support	$5.103 billion	$0.451 billion	9.70%	$10,419
Compensatory support for Scenario A	$6.438 billion	$1.786 billion	38.40%	$13,144
Compensatory support for Scenario B	$6.719 billion	$2.067 billion	44.40%	$13,717

Discussion

The general impression I have of the study by Taylor et al. (2018) is that it represents a quality piece of work which has been thought through and implemented carefully. Specifically, the work demonstrates a rigorous implementation of a stochastic cost frontier analysis to investigate the cost of providing educational adequacy in Kansas. Moreover, the results of the study tell a qualitatively similar story to that of the previous cost function study. The documentation of the research steps is mostly clear, but there are some places in the text that could use some additional detail. In addition, the report was replete with many typos that could have been easily corrected prior to submission through a basic editorial review of the text and table figures. Below, I provide some discussion surrounding key concerns that arose over the course of my review.

Estimation the Funding Adjustment for Scale of Operations

A key concern I have pertains to the estimation of cost related to scale of operations. The results in Table 2 pertaining to the estimated funding adjustments for scale of operations deserve further investigation. Here, we find that the index ranges from 1.00 to 2.75. Figure 2 shows a scatter plot of current per-pupil spending and adequate per-pupil cost in 2016-17 (from report Figure 11). The corresponding text states:

> "When comparing the actual 2016-17 spending per pupil as compared to the generated cost estimates we see a U-shape for the cost estimates the mimics a shape in which the

tails of the U have a steeper slope than that of the actual 2016-17 spending. This can be observed in the figure below. This implies that the actual 2016-17 spending per pupil does not account as well for economies of scale as the generated cost."

I would argue that this contention is not entirely correct. What is concerning is the large upswing in projected per-pupil cost at higher enrollment levels. In general, cost curves that depict per-unit costs tend to decrease as the scale of production increases. This is because total costs associated with fixed inputs (i.e., those that do not vary or are less responsive to production scale) can be spread out over a larger number of units, better known as economies of scale.

Figure 2 – 2016-17 District-Level Current Spending and Adequate Cost Per Pupil

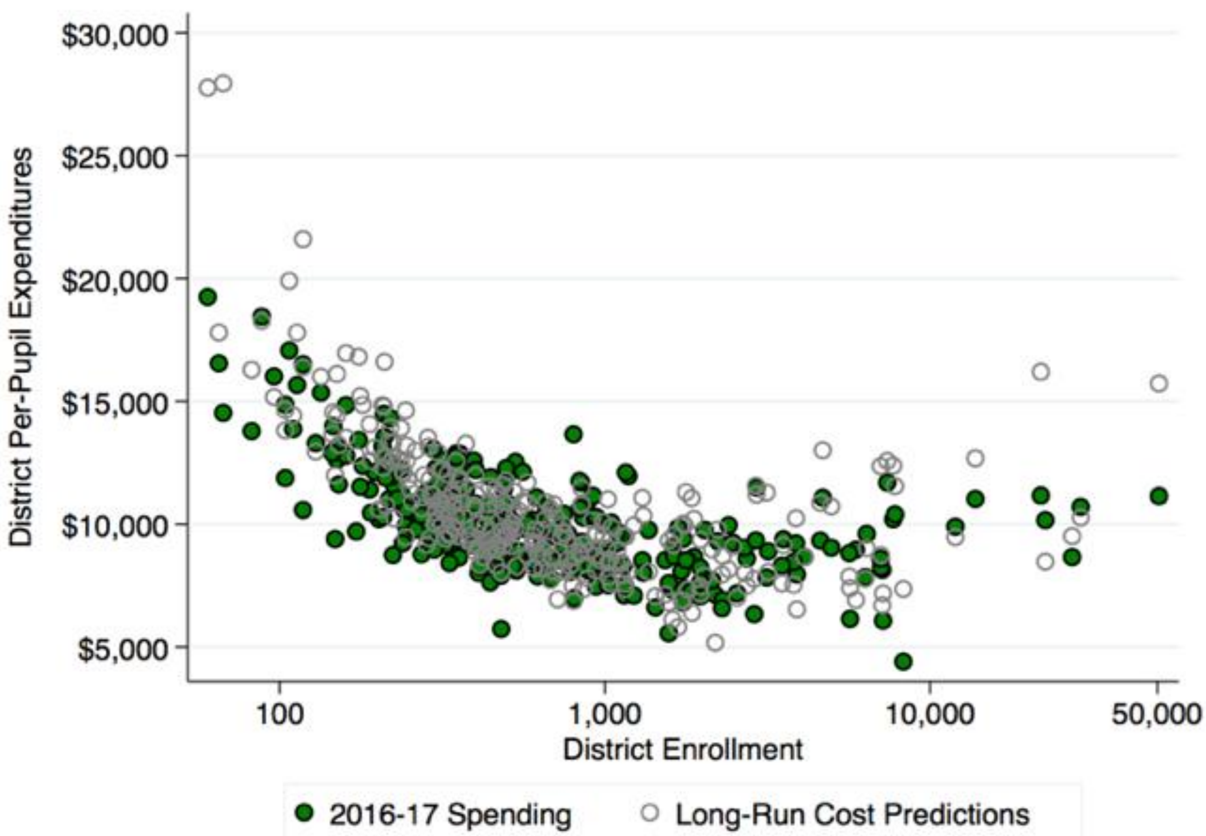


Figure copied from Figure 11 of Taylor et al. (2018).

Indeed, in educational production we often see some increases in per-student costs after a certain level of enrollment, however, the suggested funding adjustments at higher enrollments in this study are quite aggressive. In my opinion, this result is more of a direct consequence of the functional form of the cost model that was run. Specifically, the model incorporated a quadratic enrollment term in order to estimate a curvilinear relationship between enrollment and cost. However, it could be argued that this modelling decision is overly restrictive and responsible for the close to symmetric scale funding adjustments around the size associated with the minimum scale funding adjustment. To see this, consider Figure 3, which simply plots the estimated scale index values by the log of enrollment (note that the model used log enrollment and log enrollment squared). Note that from the minimum enrollment the function decreases and eventually reaches a minimum in the range 3,750 to 3,950 students (see figures in Technical Appendix D of the report). At enrollments above 3,950, the scale index increases in a symmetric fashion and tops out at 1.97[8] so that larger districts would be funding at about twice the level as otherwise similar districts in the minimum range mentioned above. This is in contrast to research that finds economies of scale to be present up until approximately 2,000 to 4,000 students (Andrews, Duncombe & Yinger, 2002). While there is some evidence that cost may increase for larger districts, this has been associated with the interaction of poverty and student density (Kansas Legislative Post Audit Division, 2006). Moreover, while these factors are both most often correlated with enrollment, both poverty and density were already controlled for in the model run by the authors.

Figure 3 – Estimated Economies of Scale Funding Index by Enrollment for All Districts

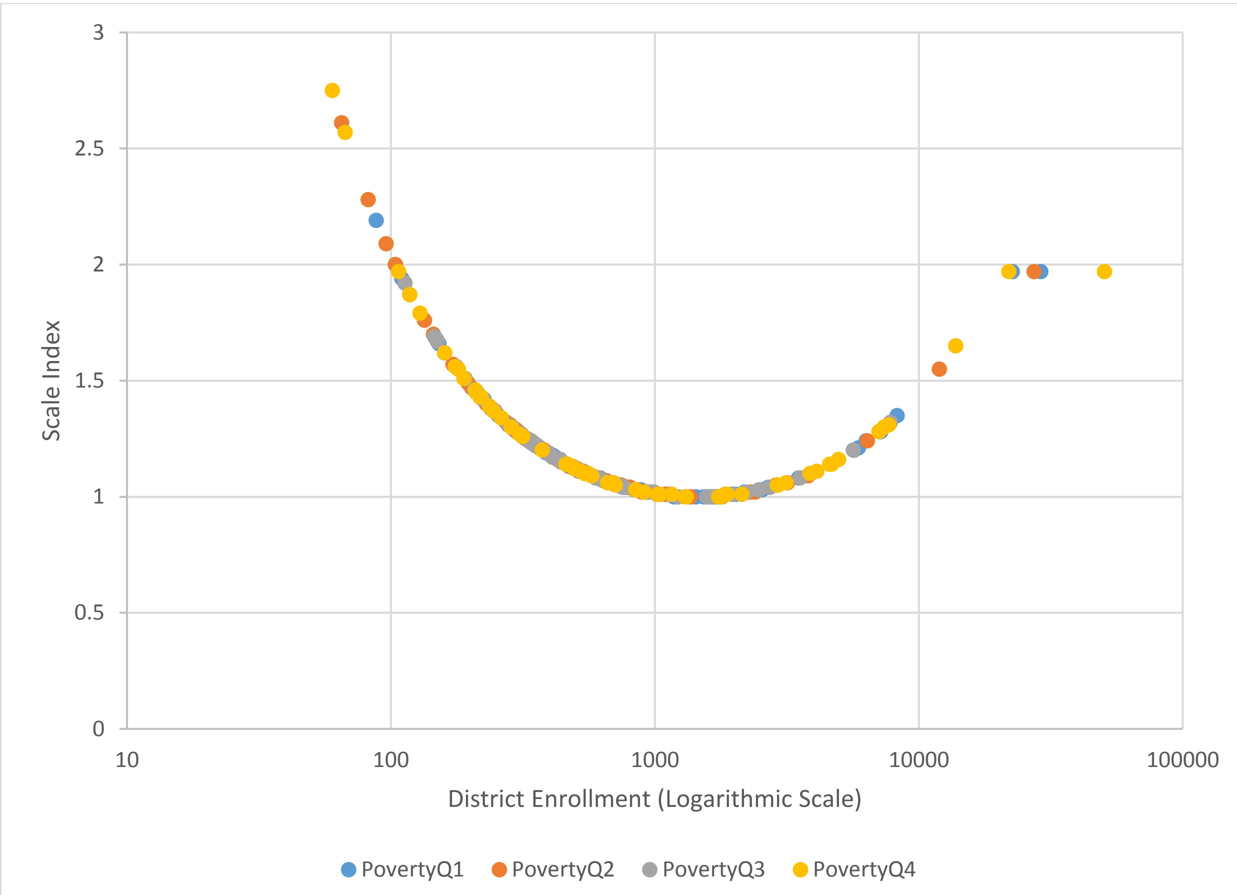


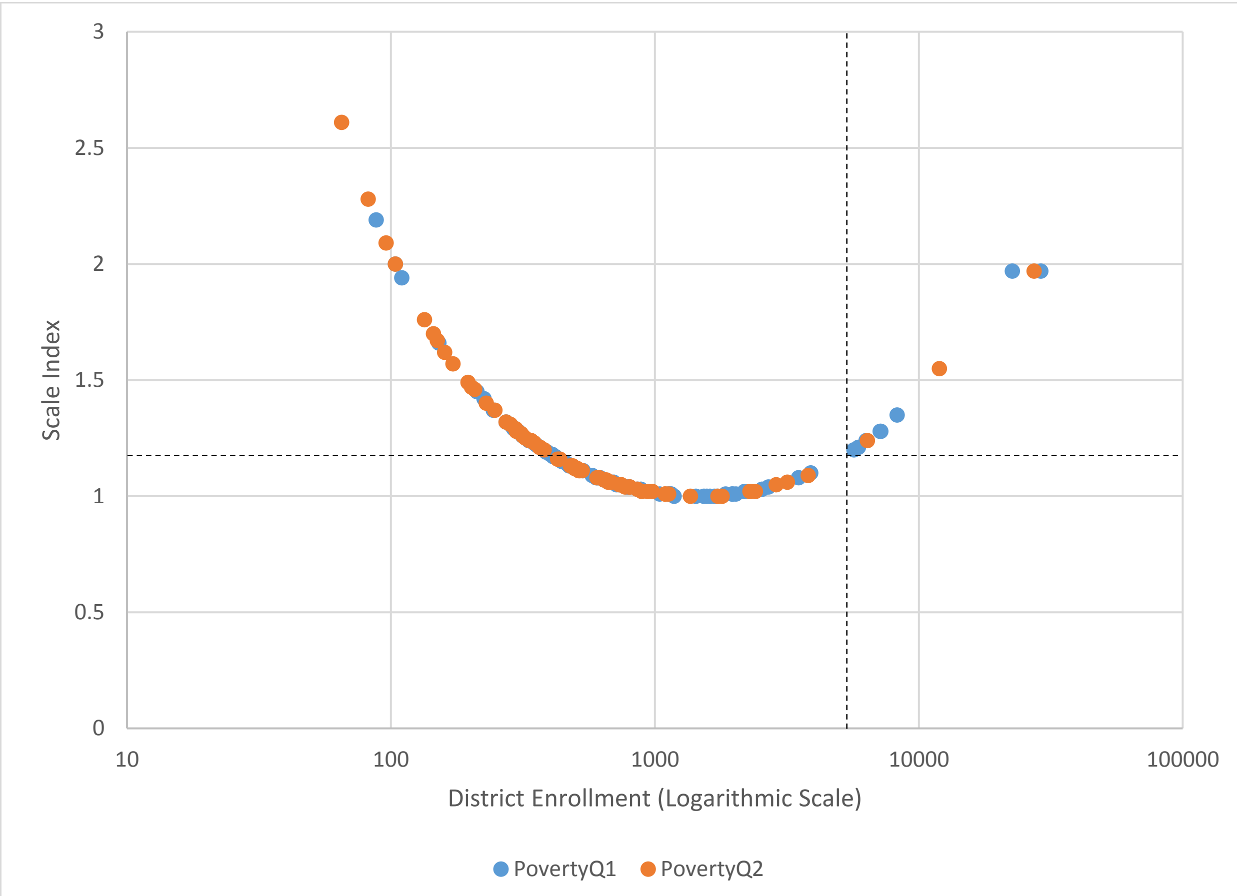
Figure derived from data in Technical Appendix E.

It is also somewhat concerning that there are many relatively low-need but large districts that appear at this upper end of the enrollment range and would greatly benefit from the aggressive scale funding adjustments. Figure 3 includes different colored plots for districts according to the quartile of the 2016-

[8] Note, I believe this maximum was imposed by the authors through top-coding enrollment for four districts that were larger than Kansas City (21,937 students). See page 85 of the report.

17 statewide poverty distribution in which they belonged.[9] However, Figure 4 provides a more readable diagram, which only graphs those less needy districts in the lowest two quartiles of student poverty (i.e. the bottom half of the statewide distribution of district poverty). As an example of some of the implications of the suggested scale adjustment, consider the plotted points in the upper right portion of the chart. This includes 38 districts that are evenly split between the first and second poverty quartiles. The minimum scale index value for the full group is 1.20, while 5 are above 1.35, and 3 assume the maximum scale adjustment of 1.97.

Figure 4 – Estimated Economies of Scale Funding Index by Enrollment for Lower-Poverty Districts (Poverty Quartiles 1 and 2)



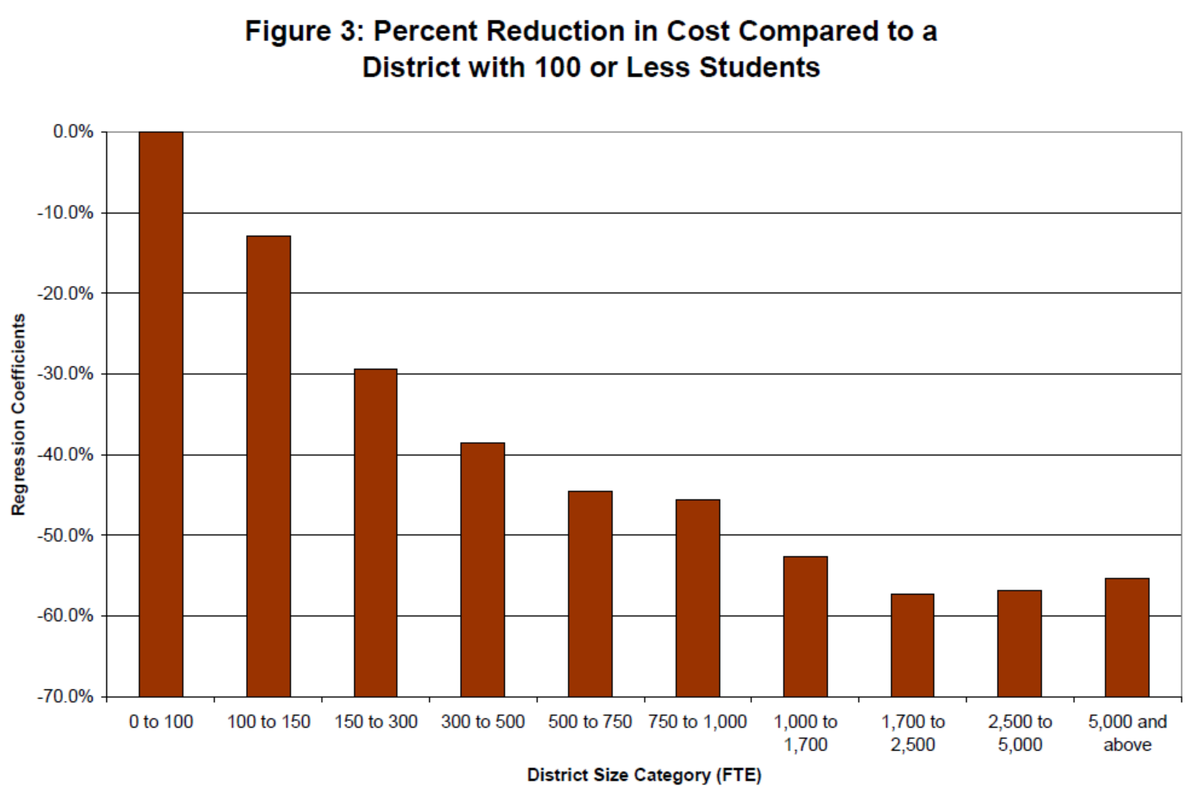
In turn, it seems that the aggressive increase in the suggested scale funding index with respect to larger district enrollments was driven by the way functional form in which enrollment was accounted for in the model specification. Importantly, I do not see anything wrong with the estimated funding adjustments for lower enrollment districts (i.e., those with enrollments that are smaller than those associated with

[9] The definitions of the poverty quartiles are as follows: Quartile 1-Less than 27 Percent; Quartile 2-Between 27 and 35 Percent; Quartile 2-Between 35 and 46 Percent; and, Quartile 4-Greater than 46 Percent.

the minimum scale index value). Rather, it is the large increase in scale index values for enrollment levels above this point that is of concern.

Fortunately, there is a very simple way to address this issue. Specifically, one can empirically try to estimate the model that specifies enrollment using a different functional form or not restricted the spending/cost relationship to assume any particular form at all. Specifically, the researchers could follow a similar approach to that taken in the study by LPA (Kansas Legislative Post Audit Division, 2018) by including discrete indicators of district enrollment categories. The LPA study included nine such indicators, which produced the expected relationship as shown in Exhibit 5. Here, the smallest districts proved to be the most expensive on a per-pupil basis (all other things equal), with per-pupil cost declining until the 1,700 to 2,500 student category, at which point costs rise slightly. Note that inherent in the strategy is the top-coding of enrollment (at 5,000). However, while enrollments were top-coded in the study by Taylor et al. (2018), this alone would not likely solve the specification problem encountered (i.e., the quadratic enrollment term forces the enrollment-cost relationship to be parabolic so that the cost function must increase and may do so dramatically).

Exhibit 5 – Cost Adjustments by Enrollment Category as Estimated in Kansas Legislative Post Audit Division (2018)



As a practical matter, the researchers should have attempted to calculate the additional costs associated with providing the scale funding adjustments for districts above a given threshold enrollment level (e.g., above 5,000).

Hold Harmless Funding and Formula Phase-In

In describing the application of the estimated per-pupil base and various funding adjustment indices (regional, scale, student needs and compensatory) the authors are very clear that their calculations maintain the actual funding levels for those districts that are already meeting or on target to meet the outcome targets (i.e., these districts are held harmless):

> "Districts that are currently outperforming the thresholds and those growing faster than necessary to reach the targets within five years are held harmless in this calculation, so that the compensatory support estimate includes the funds required to at least maintain current levels of annual progress in all districts." Page 65 (Taylor et al., 2018)

Unfortunately, the authors make no effort to calculate at what cost implementing this hold-harmless decision would come. In addition to a monetary cost in terms of funding districts at a level that is *more* than is deemed necessary per the cost model results, effectively funding inefficiency, hold harmless arrangements also undermine the equity intent of an adequacy-based funding formula.

This is not to say that providing some degree of hold-harmless for at least a temporary period is unwarranted. To the contrary, it would be irresponsible to require those districts with adequacy projections that are lower than current spending to switch over to a smaller funding allocation overnight. This could result in severe uncoordinated shocks to the delivery of important education programs and services. To this end, previous studies have discussed how district support through hold-harmless provisions might be gradually phased out as part of the formal plan to phase in a new funding formula (Chambers et al., 2008a,b).

The authors do nothing to address this, which suggests that the suggested hold-harmless provision was perhaps intended to be a permanent fixture. Indeed, they do make brief mention of a phase-in, but do not include anything about the hold-harmless provision included in their estimates. In any case, regardless of the intended permanency of the hold-harmless provision, the costs associated with this need to be calculated and reported.

Modelling Inefficiency

As discussed above, the model attempted to both control for technical (in)efficiency both directly and indirectly. Specifically, a stochastic cost frontier model is designed to estimate how far of the minimum cost frontier each district is. In addition, indirect measures of efficiency were also included in the model specification with the following results:

Table 5 – Model Estimates of Efficiency Factors

Variable	***Estimates of Coefficients and Standard Errors***
Herfindahl Index, log	0.797*** (-0.249)
Border metro	2.320*** (-0.372)
% Owner occupied	7.293*** (-1.321)
% Over 60	-2.316 (-1.496)
% College	-12.06*** (-1.542)
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 Results taken from Table 20 in Taylor et al. (2018).	

The first two variables are the Herfindahl index (a measure of concentration of schools in the education market) and whether a district is located in a district that spans a state border. The resulting coefficients were in line with findings from previous research; less market competition is associated with lower efficiency and greater spending. The other three variables, the percent of owner-occupied houses, percent of population over the age of 60, and the percent of population with at least a bachelor's degree are all variables that indirectly measure the degree to which public institutions (such as schools and districts) are monitored and held accountable. While the percentages of the population that is over 60 and with a bachelor's degree yielded model point estimates that coincided with expectations (i.e., they were associated with higher efficiency and lower spending), the percent of owner-occupied houses produced an effect that was the opposite of what would be expected. The explanation for this finding was that it may represent spending on outcomes that, while valuable (especially perhaps to home owners), were not included in the model and therefore considered inefficient. I do not doubt this as a possible explanation, however, I am wondering if this finding poses more of a challenge to the conventional wisdom and our expectation that this coefficient should be negative. Perhaps we should only expect it to be negative conditional on including all pertinent outcomes in our model.

In addition, the authors could have included more about the efficiency estimates. Specifically, while Finding #1 provides the distribution of cost efficiency estimates, formal reporting of the results of a significance test would be most welcome. The authors mention in footnote 11 that cost efficiency was estimated using the method suggested by Battese and Coelli (1995). In addition, the text mentions that inefficiency (termed the one-sided variable function) was modeled as a linear combination of five indirect efficiency measures assuming the one-sided error follows a half-normal distribution. I am wondering if the authors experimented with better understanding the potential heterogeneity of efficiency across districts.[10]

Validity Checks

As mentioned in the previous review of the Kansas costing-out studies by Augenblick & Myers and the Kansas Legislative Post Audit Division (Levin, 2018), it is important to run validity checks on the results of a costing out study. One type of validity check described in that review was to analyze the relationship between the predicted shortfall in funding and student outcomes across districts. The idea is as follows. In order to provide an equal opportunity for all students to achieve a state's educational goals adequate levels of funding must be provided in an equitable manner. In turn, determining how funding should be distributed to districts is one of the fundamental purposes of a costing-out study.

In turn, it is important to validate the results of a costing-out study by evaluating the relationship between the projected additional funding necessary to provide an adequate education and the outcomes such as student achievement (adequate cost). As stated in the earlier review:

> "If the model is working as intended so that adequate funding is provided in an equitable manner that affords all students an equal opportunity to achieve regardless of their needs or location, then we should see a systematic relationship between a

[10] For example, the Stata *frontier* procedure allows the user to specify the one-sided inefficiency error to follow a truncated normal distribution and model the average efficiency with covariates (see entry for frontier in Stata manual, pages 9-10).

district's relative need (how much more/less they need to provide a sufficient education) and student outcomes such as achievement on standardized tests."

Unfortunately, the study by Taylor et al. (2018) did not perform such a check. In an effort to better understand the validity of their results, I have taken the liberty of running this check following an analysis similar to that used for other large-scale costing-out studies in New Mexico (Chambers et al., 2008a) and New York (Chambers et al., 2004a; Chambers, Levin & Parrish, 2006). The analysis involved first calculating the funding shortfall or *Adequacy Gap* for each district. This measure is the relative difference between the projected adequate per-pupil cost and actual per-pupil spending defined as follows:

(2) Adequacy Gap = Adequate Per-Pupil Cost / Actual Per-Pupil Spending

Clearly, values that are greater than 1.00 indicate that the district needs more than it is currently receiving to provide an adequate education (i.e., there is a relative shortfall in funding), while values that are less than 1.00 imply that the district is getting more than it needs to achieve adequacy (i.e., there is a windfall in funding).

To facilitate this analysis, I first required a measure of actual current expenditure per pupil, as I did not have the study data at my disposal. To this end, I obtained the most recent (2015) district-level fiscal data available from the U.S. Census Annual Survey of Public School Finances or "F-33" data and used the Consumer Price Index (CPI) for the Midwest states to inflate the dollars to 2016 (the same year as the adequacy projections calculated by Taylor et al. (2018)).[11] However, to make the current expenditures from the F-33 compatible with the current expenditure definition the authors used with the Kansas state fiscal data, I removed spending on transportation and food. The calculated statewide average current spending per-pupil was $9,266, or less than one percent lower than the $9,333 calculated in the study using KSDE fiscal data.[12] The per-pupil adequacy costs for districts were derived from the figures in Appendix E of the author's study.

Along with the district-specific ratios of adequate cost to actual spending, the analysis required student outcomes. I therefore obtained publicly-available data from the Kansas State Department of Education on school-level percentages by performance level categories 1 through 4 on the KAP ELA and math assessments for grades 3 through 8 and 10.[13] These percentages of students within each performance level were then averaged across grade level and schools within each district. Finally, two sums of the district average percentages were calculated:

1) Percentage of students scoring at performance level categories 2, 3 and 4 (old standard)
2) Percentage of students scoring at performance level categories 3 and 4 (new standard)

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[11] To inflate the F-33 figures from 2015 to 2016 dollars, I used the CPI for all urban consumers in the Midwest states (series CUUR0200SA0 available here: https://data.bls.gov/pdq/SurveyOutputServlet?data_tool=dropmap&series_id=CUUR0200SA0,CUUS0200SA0).

[12] While the current expenditure figures I derived from the F-33 data are on a statewide average very close to those calculated by Taylor et al., it seems that the omission of food and transportation may have taken out too much spending given the large numbers of districts with calculated adequacy gaps that fall below 1. Nevertheless, the metric should still serve as a general measure of relative need for funding for our purpose.

[13] These data can be downloaded at: http://ksreportcard.ksde.org/assessment_results.aspx?org_no=State&rptType=3.

The analysis itself involved generating the scatter plots in Exhibits 5 through 8. The graphs plot (on the y-axis) the district-level average percentages of students across grades who are scoring at level 2 and above or at level 3 and above, respectively, on the KAP ELL and math assessments against district funding shortfall. Each plotted point (circle) represents a school district with the size proportional to its enrollment. The downward sloping line shows the pupil-weighted relationship between student outcomes and funding shortfall. The horizontal dotted line represents the target rate that the study by Taylor et al. (2018) used as proficiency targets to be achieved by 2030 under the old (Scenario A) and new (Scenario B) standards (i.e., 90 percent of students performing at level 2 or above and 60 percent of students performing at level 3 or above, respectively).

The scatter plots tell a consistent story on several fronts. First, the relationships between funding shortfall and student outcomes prove to be negative. That is, achievement on the state's standardized ELA and math tests tend to be lower the larger is the relative need for funding determined by the study performed by Taylor et al. (2018).

Exhibit 5 – District-Level Percentages of Students Scoring at Level 2 or Above on KAP ELA by Funding Shortfall (2016-17)

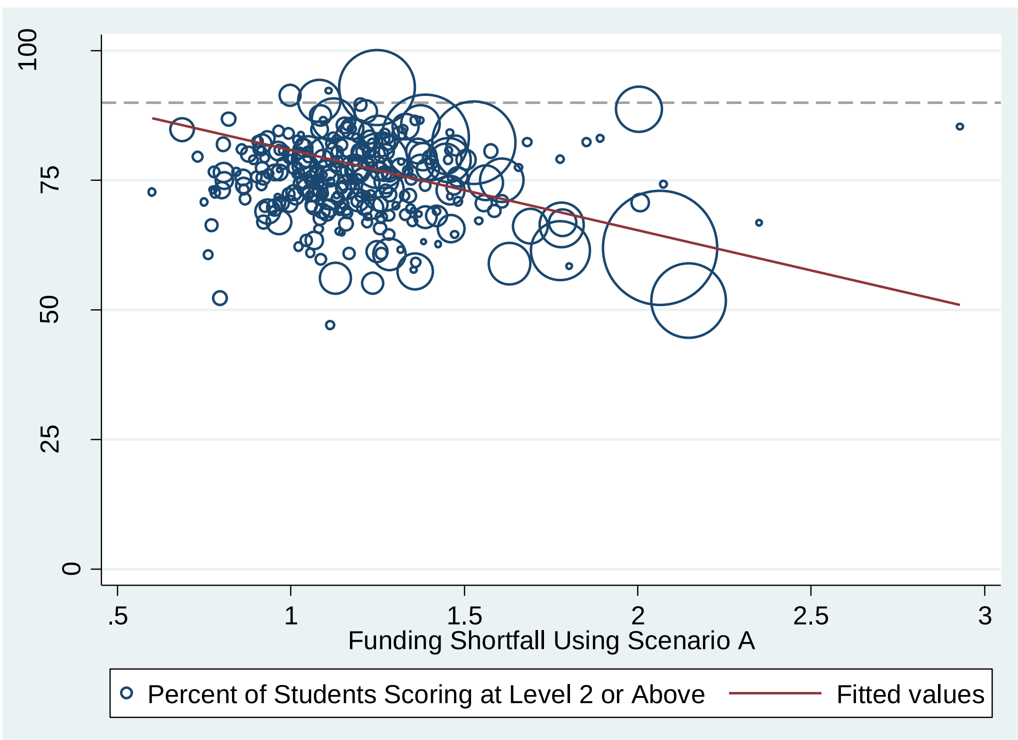


Exhibit 6 – District-Level Percentages of Students Scoring at Level 3 or Above on KAP ELA by Funding Shortfall (2016-17)

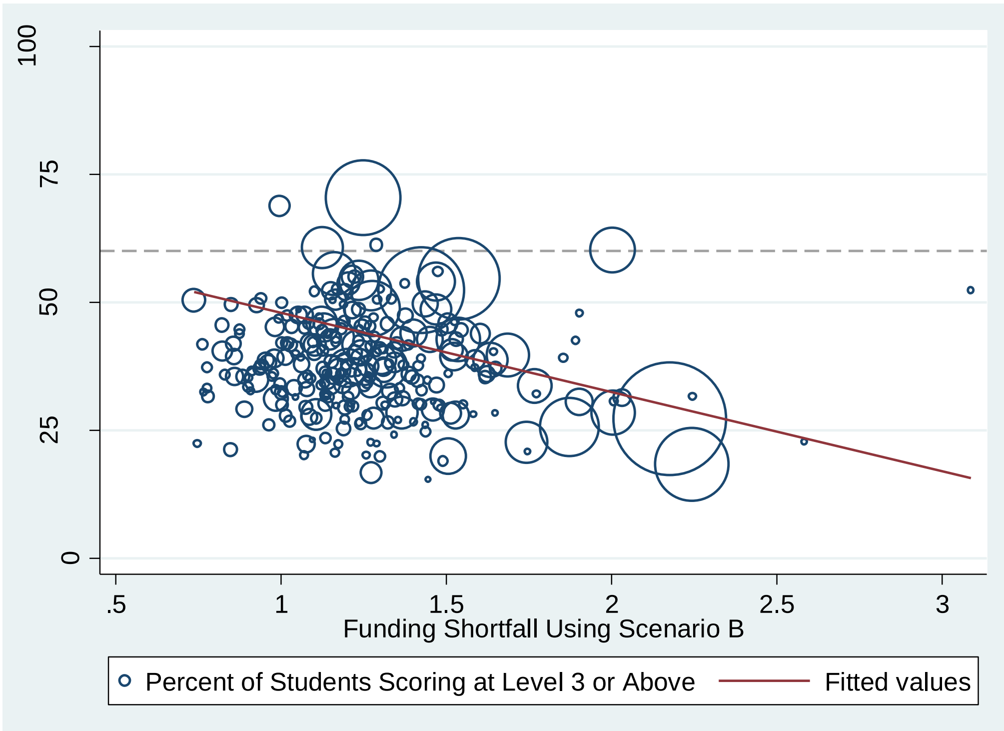


Exhibit 7 – District-Level Percentages of Students Scoring at Level 2 or Above on KAP Math by Funding Shortfall (2016-17)

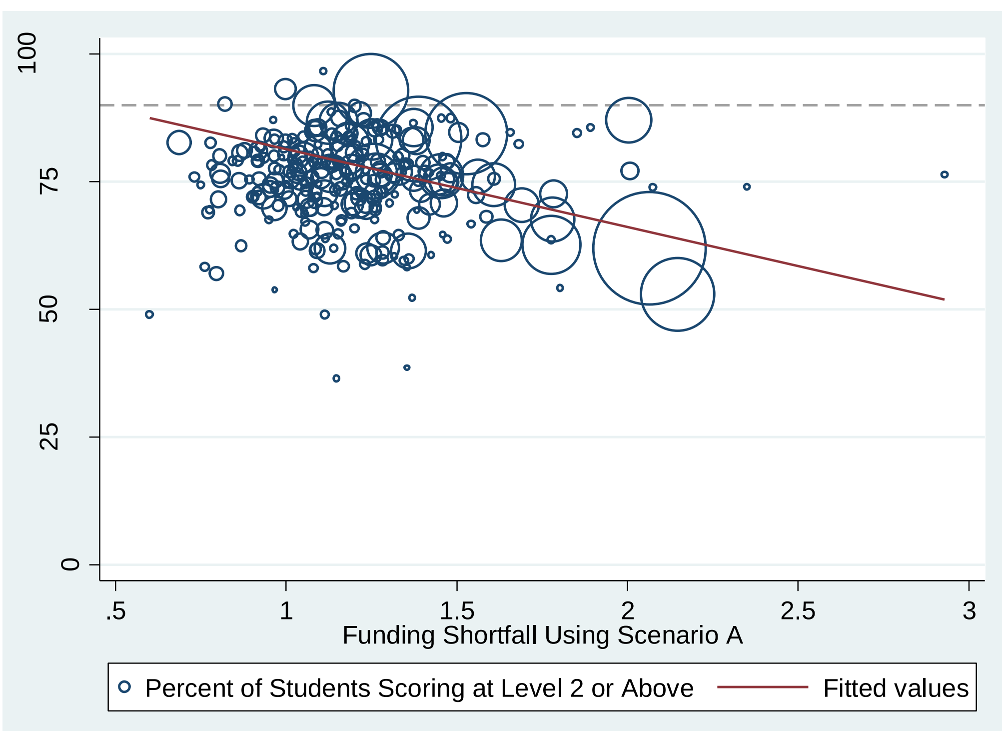
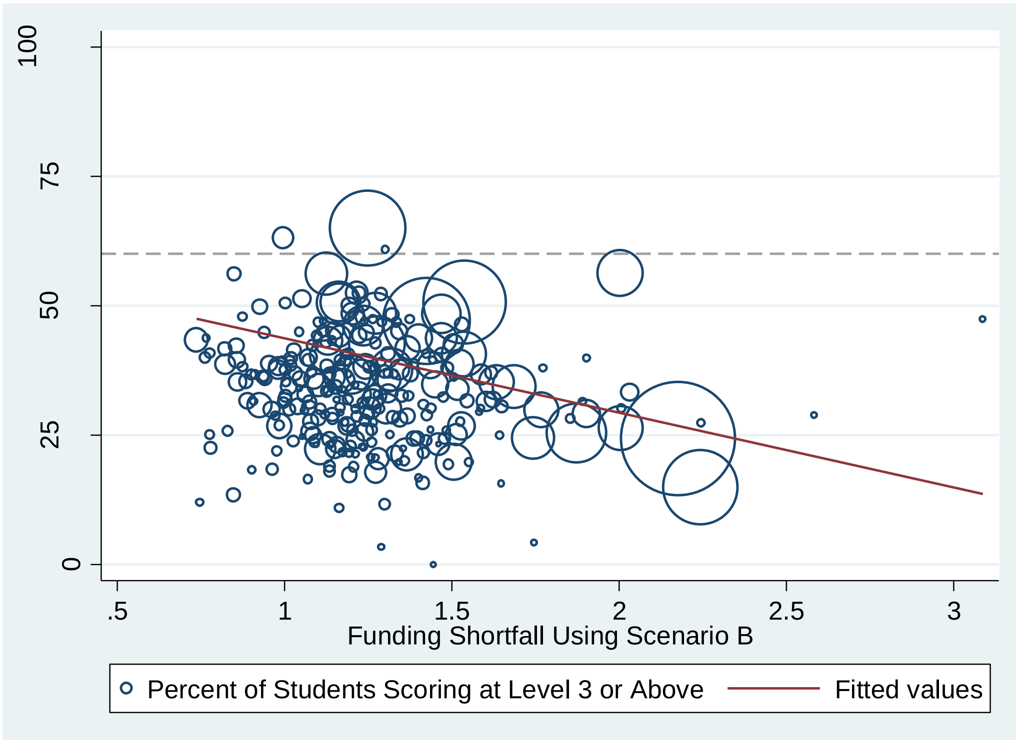


Exhibit 8 – District-Level Percentages of Students Scoring at Level 3 or Above on KAP Math by Funding Shortfall (2016-17)



This finding is reinforced by the pupil-weighted correlations between funding shortfall and outcomes presented in Tables 6 and 7. The correlations range from -0.5360 to -0.4427 and all are statistically significant ($p<0.001$). In turn, this provides validation for the study findings. Second, there are few districts that are currently meeting the outcome threshold as defined by either the old or new standards. Those districts that are coming close to meeting the threshold tend to have smaller funding shortfalls. Third, bigger districts tend to have larger funding shortfalls. However, note that this latter finding is likely driven at least in part by the scale of operations cost index issue put forth above.

Table 6 – Correlation Between District Funding Shortfall and Average Percent of Students Scoring at Level 2 or Above on KAP ELA and Math Assessments

	Percent Scoring at Level 2 or Above – ELA	*Percent Scoring at Level 2 or Above – Math*
District Funding Shortfall	-0.5360	-0.5422

Table 7 – Correlation Between District Funding Shortfall and Average Percent of Students Scoring at Level 3 or Above on KAP ELA and Math Assessments

	Percent Scoring at Level 3 or Above – ELA	*Percent Scoring at Level 3 or Above – Math*
District Funding Shortfall	-0.4584	-0.4427

Translating National Curve Equivalents to Proficiency Rates

One of the key pieces of documentation that I found missing from the study was an explanation of how the National Curve Equivalents translate into proficiency rates on the KAP assessments. A considerable amount of thought (indeed a whole chapter of the study) was devoted to considering the Rose standards and how these could be crosswalked to measurable student outcomes. Thresholds of proficiency on the KAP assessments were chosen based upon a review of 1) the performance of high achieving districts (i.e., those at the 90^{th} percentile of performance), 2) the State's ESSA plans, and 3) historical performance in periods where the State's constitutional obligation to adequately fund schools. The study also provided a good description of conditional National Curve Equivalent (NCE) measures, which were used as one of two key student outcome measures in the stochastic cost frontier model. However, there is no description of how the cost estimates associated with the NCE measures were translated into the KAP performance thresholds in order to calculate the compensatory costs under Scenarios A and B. This is not to say that the authors did anything wrong here. Rather, it is totally unclear how this was done.

4 – Comparing the Results of the Cost Function Studies

A logical question to ask is how might the results of the two cost function studies (Kansas Legislative Post Audit Division, 2006; and, Taylor et al., 2018) compare. Furthermore, how can any differences in the main findings of these studies be explained. The following section attempts to shed some light on these questions using simple statistical analysis and details from these works.

An obvious place to start is to compare the adequate per-pupil costs projected for districts in both studies. The additional costs to achieve adequacy reported by the two studies are included in both absolute and relative terms in Table 8. Unfortunately, a direct comparison of these figures is not all that useful due to several factors. First, the studies were performed on data that differed in age by 10 years and the value of the dollar has changed greatly over this period (i.e., inflation erodes the value of the dollar over time). However, that is easily addressed by simply inflating the figures from the older study. This transformation was done by applying a ten-year inflation rate from 2006 to 2016 (18.8 percent) derived from the same CPI data mentioned above to the $399.3 million necessary increase in funding reported in the LPA study (Kansas Legislative Post Audit Division, 2006).[14] The third column of the table shows that the $399.3 in 2006 dollars inflated to 2016 would be $475 million.

However, even after inflating the cost figure from the older study the direct comparison of figures between the two studies may not be appropriate. First, the older cost study excluded a portion of federal funding that could be used to support base, at-risk, and bilingual education in order to avoid a situation that could be interpreted as supplanting. Specifically, they excluded a total of $205.5 million from their adequacy calculations in 2006 dollars, which would be equivalent to $244 million in 2016 (using the same Midwest CPI mentioned above). Adding back the 2016 equivalent of the federal dollars excluded from the calculation in the older study provides a more appropriate number with which to compare the figures from the two studies. The estimated additional cost from the LPA study inclusive of the federal dollars is $719 million or 15.5 percent higher than current K-12 spending.

[14] Specifically, I made use of the CPI for all urban consumers in the Midwest states (series CUUR0200SA0 available here:
https://data.bls.gov/pdq/SurveyOutputServlet?data_tool=dropmap&series_id=CUUR0200SA0,CUUS0200SA0).

Table 8 – Measures of the Additional Cost to Achieve Adequacy (in Billions of 2016 Dollars)

	Current K-12 Spending in 2016 Dollars	***Kansas Legislative Post Audit Division 2006 Dollars***	***Kansas Legislative Post Audit Division Inflated to 2016 Dollars***	***Kansas Legislative Post Audit Division Inflated to 2016 Dollars With Federal Funding***	***Taylor et al. - Scenario A in 2016 Dollars***	***Taylor et al. - Scenario B in 2016 Dollars***
Necessary Absolute Increase (in Billions of 2016 Dollars)	$4.652	$0.399	$0.475	$0.719	$1.786	$2.067
Necessary Relative Increase	n/a	n/a	10.2%	15.5%	38.4%	44.4%
Includes Federal Dollars	√	×	×	√	√	√
Includes Food Service and Transportation	×	√	√	√	×	×

Another reason that the numbers are not comparable is the fact that the new study excluded spending on food services and transportation from their calculations, while the study by LPA did not. This spending would increase the additional cost suggested by the new study, however, deeper investigation into the how much this increase might be is outside of the scope of this review.

Other reasons that might account for the differences in the adequacy costs suggested by the two studies can be attributed to the differences in methodology. The following describes two such reasons that likely play a significant role in explaining differences between the findings of the two studies.

- Use of Input- versus Outcome-Based Methods – The older cost study implemented a combination of input- and outcome-based methods to calculate different types of expenditure. Specifically, this hybrid approach included input-based estimates of several categories of *spending* as opposed to *cost*, including expenditures on the base program, as well as special education and vocational education. Note that the estimates for this spending cannot be considered cost-based because outcomes and other factors such as student needs and scale of operations were not taken into account.

  As mentioned in the first review report (Levin, 2018), this resulted mixing results from an outcome-oriented approach that measured the *cost* of providing educational adequacy, with those of the input-oriented approach intended to get at the spending necessary to provide levels of programming and services regarded as minimally required by law or regulation. Moreover, the calculation of spending was erroneously based on districts with the lowest utilization of many types of staff and non-personnel resources in the name of "efficiency". In turn, the calculated spending for the core base program, special education, and vocational education by the older study underestimated the true cost of providing adequate educational services in these areas. In contrast, spending for both special education and vocational education were included in the cost estimates for the newer study. I would contend that this key difference in method likely accounts for at least a portion of the difference in the respectively findings.

- Differences in Student Outcome Measures – Both studies used different measures and thresholds of student outcomes to define adequacy. While the newer study made an attempt to approximate the old testing standards using the performance levels of the new assessment system, to the extent that the new standards and tests are more difficult one would expect the newer estimated costs of achieving adequacy to reflect this.

Despite the differences in the findings of the two independent cost studies, it is crucially important to acknowledge that the qualitative stories they tell are similar. That is, both studies point to a need for significant additional funding to support an adequate education in the state. To show this from a statistical perspective I have run an analysis of the pupil-weighted correlation between the district-level calculations of adequate per-pupil spending generated by the two cost model studies. The results of this analysis show that despite the differences due to the changes in school and district characteristics that may have changed over time and the methodological differences in how the figures were calculated there is still a strong relationship between the projected district-level adequacy costs per-pupil generated by the two studies. Table 9 lists correlation coefficients between the old and new cost estimates equal to 0.7280 (Scenario A) and 0.7342 (Scenario B), which are both highly significant ($p<0.001$).

Table 9 – Correlations Between Projected District-Level Adequate Per-Pupil Costs from the Two Cost Studies

	Taylor et al. – Scenario A	***Taylor et al. – Scenario B***	***Kansas Legislative Post Audit Division***
Taylor et al. – Scenario A	1		
Taylor et al. – Scenario B	0.9957	1	
Kansas Legislative Post Audit Division	0.7280	0.7342	1

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