Funding Michigan K-12 Adequacy Without Rewarding Inefficiency

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Taxpayers and politicians expect public schools to exercise stewardship and wisdom regarding the use of resources entrusted to them. These public expectations approximate what economists refer to as technical efficiency. Technical efficiency emerges from the ideal use of available resources for maximizing output whereas allocative efficiency derives from comparing alternative technically efficient systems and choosing the least costly option.[1] A third and more obscure type of efficiency emerges in economic analysis from an interpretation of the unobserved effects of the entity studied. This phenomenon is sometimes referred to as "x-efficiency." Its significance comes from the unobserved effects of vision, motivation, incentives, and the culture of the entity and its leadership.[2]

Evidence exists that qualitative factors such as clearly defined goals, uninhibited access to information regarding these goals, incentives, motivation and effort, often the fruit of competition or adversity, yield far greater output improvement compared to marginal changes in inputs.[3] Quantity times price may generate a variety of results depending on these unobserved factors. Improving student achievement by accomplishing changes in school organizational behavior represents direct application of x-efficiency.

The analysis in this study draws heavily on the notions of both technical efficiency and x-efficiency. Both of these lend themselves to an input/output style of inquiry like the education production function. This economic model builds on the foundation of the Cobb-Douglas factors of production theory although the genesis of that theory relates to industrial not educational formulations.[4]

Research Design

The goal of this study was to estimate the effects of district efficiency on student achievement in Michigan with the hope that objective analysis might serve to ease progress through the troublesome political process any transition to an adequacy-based school finance model will encounter. This study draws upon the methodology used by Phelps and Addonizio in their 2006 study of school accountability in Minnesota.[5]

Michigan does not track student achievement data by individual teacher or per pupil expenditures by school, only by district. Were per pupil expenditure available by school, the flow to individual students would require reliance on assumptions and averages. The unavailability of test score data by classroom or teacher, combined with the lack of reliable per pupil expenditure data by school and the abstraction caused by artificial resource flow assumptions, prompted the study's use of the district as the unit of analysis. District level data for MEAP (Michigan Educational Assessment Program) scores and per pupil expenditure came from the State of Michigan website.

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The operative version of the theoretical education production function for use in this study appears below:[6]

$$M_t = b_0 + b_1 pctenroll + b_2 avg\_t\_sal + b_3 avg\_p\_tchr + b_4 avg\_isal + b_5 avg\_totexp\_ntr + u + e$$

Where

M represents statewide Michigan Education Assessment Program (MEAP) reading and math scores, stated as the percentage of students taking the test who achieved at a level meeting state standards;

pctenroll equals the percentage of students in a district eligible to receive free or reduced-pric meals under U.S. federal guidelines;

avg_t_sal denotes the average teacher salary in the district;

avg_p_tchr is the average number of pupils per district teacher;

avg_isal is the average per pupil district expenditures related to instructional salaries;

avg_totexp_ntr controls for total district expenditures per pupil, net of transportation;

"u" signifies the portion of the residual that does not vary over time but does vary by district (This can be referred to as the district fixed effect and is estimated following regression);

"e" signifies the random portion of unobserved, residual, or unexplained variation.

Analysis of the residuals in the fashion indicated above requires retrieval of multiple observations for each district over time. This study includes a balanced panel of observations for districts over four years starting with the 2001-2002 school year through 2004-2005. The average residual by district was used to proxy for the district fixed effect in second stage regressions.

Although the model specified above contains no variable for district size, the regression technique used for this study was weighted by the full time equivalent student population for each district in each year. This adjusts for district size and mitigates the lack of constant variance in the residuals (heteroscedasticity) which represents one of the basic assumptions underlying linear regression.

Analysis of Data And Results

Data Description

Data were collected from public files available on the websites of the Michigan Department of Education (MDE) and Center for Educational Performance and Information (CEPI). Data for the dependent variable came from MEAP scores maintained by the Office of Educational Assessment and Accountability (OEAA) of the MDE. The second file type contained district financial information called Bulletin 1014 administered by the MDE Office of State Aid and School Finance. Data for student eligibility for federal meal subsidies came from information contained in the Single Record Student Data base controlled by CEPI. A file representing various measures of a single element in this database called Free and Reduced Lunch (FRL) appears on the CEPI website.

Bulletin 1014 files contained the most accurate district count as verified with the School Code Master file maintained by MDE. The number of districts reporting in Bulletin 1014 for the years included in the panel from 2001-2002 through 2004-2005 school years as follows: 743, 742, 744, and 760. However, only 494 districts reported data for every field used in the model for every year in the panel. The primary source for this discrepancy comes from counting each charter school as a separate district.[7] However, several traditional districts were excluded from the study panel. Some traditional school districts in Michigan do not offer all twelve grades. For the study, any district that did not offer either seventh or eighth grade was necessarily eliminated from the panel. Also, MEAP scores are not reported in the public files for districts with fewer than ten test-takers in a grade.

Descriptive statistics for the 494 district panel are presented in Table 1. The summary of the dataset contained in Table 1 represents the same 494 Michigan school districts observed across four years for a total of 1,976 observations. The means and standard deviations reported for each explanatory variable were determined after weighting each variable by the inverse of variance for the student population. This technique is useful for observations containing averages. Averages based on the number of observations grow in precision as the number increases. Weighting provides the means to concede greater importance to the more precise measurements.[8] Weighting considers the variation in the data by student although the unit of analysis remains aggregated by district.

Preliminary Annual Test Results

A preliminary set of sixteen regressions for all four measures of student achievement and separately for each of the four years served several purposes. Review of model specification, fit, and model diagnosis represented the primary motivation. The regressions were weighted by the student population of each school district as discussed above. This procedure corrected for the anticipated lack of constant variance in the model error term caused by the wide variance in district size as measured by the number of students. This heteroscedasticity represented the principal diagnostic problem related to the underlying assumptions for least squares regression. The weighting methodology provided significant improvement but did not entirely correct the problem for all years in the study.[9]

Analysis of Residuals

Some variation in the student achievement measures from the regressions referred to above remained unexplained. These residuals contained the fixed but unobserved effect of the district plus random error.[10] The average residual for each district was used to investigate systematic achievement above or below that predicted by the explanatory variables in each year. The result was assumed to measure the extent to which the district benefited from "x-efficiency," or contribution to student achievement not captured by the variables specified in the model. This estimate of district fixed effect was used as an explanatory variable in second stage regressions.

This simple averaging method for estimating district fixed effects was used after several attempts at fixed effects regression models failed to untangle the high correlation between the explanatory variables and fixed portion of the residual.[11] This correlation also proscribed the use of random effects or generalized least squares methodology.

Post Estimation Annual Test Results Including Fixed Effects Estimates

The sixteen regression results in Tables 2-5 came from estimating the same model described, but not presented, for preliminary annual tests, with one exception. The models estimated here included the variable determined in the previous section to represent the fixed effect of each district (avg_resid). This variable represented a relative measure of each district's contribution to the percentage of students meeting or exceeding state standards after controlling for the other predictors. The residual was averaged for each district using the results of the preliminary regressions for MEAP math and reading tests in fourth, seventh, and eighth grades. The results were analytically weighted by

Table 1
Descriptive Statistics, 2002–2005

Variables	Observations	Weight	Mean	Std. Dev.	Minimum	Maximum
district	1,976	6,438,484			1.010	83,070
year	1,976	6,438,484			2002	2005
math_gr4_sat	1,976	6,438,484	0.695465	0.143724	0.101	1
read_gr4_sat	1,976	6,438,484	0.741757	0.155611	0.13	1
read_gr7_sat	1,976	6,438,484	0.614158	0.174635	0.124	0.97
math_gr8_sat	1,976	6,438,484	0.572979	0.188827	0.057	1
pctenroll	1,976	6,438,484	0.333412	0.217264	0.02	0.9
avg_t_sal	1,976	6,438,484	54056.33	6903.321	24,547	83,479
avg_p_tchr	1,976	6,438,484	21.73831	2.565409	9	33
avg_isal	1,976	6,438,484	4663.104	585.9229	2,827	7,010
avg_totexp_ntr	1,976	6,438,484	8002.849	1294.894	5,416	15,628

Table 2
Grade 4 Math Scores Post-Estimation WLS Regression Results

	School Year			
Variables	**2001–2002**	**2002–2003**	**2003–2004**	**2004–2005**
pctenroll	-0.465***	-.0473***	-.0495***	-.0502***
	[-0.61]	[-0.63]	[-0.70]	[-0.75]
	(0.016)	(0.015)	(0.017)	(0.017)
avg_t_sal	-0.000000217	0.000000662	-0.000000596	0.000000939
	[-0.010]	[0.033]	[0-0.032]	[0.053]
	(0.00000063)	(0.00000059)	(0.00000060)	(0.00000058)
avg_p_tchr	-0.00331**	-0.00490***	-0.00720***	-0.00982***
	[-0.054]	[-0.088]	[-0.16]	[-0.22]
	(0.0014)	(0.0013)	(0.0014)	(0.0015)
avg_isal	0.0000564***	0.0000366***	0.0000473***	0.0000425***
	[0.20]	[0.13]	[0.19]	[0.19]
	(0.000011)	(0.0000095)	(0.0000095)	(0.000010)
avg_totexp_ntr	-0.0000216***	-0.0000177***	0.0000232***	-0.0000277***
	[-0.15]	[-0.13]	[-0.20]	[-0.26]
	(0.0000044)	(0.0000040)	(0.0000036)	(0.0000039)
avg_resid	1.036***	1.086***	1.125***	1.303***
	[0.60]	[0.63]	[0.69]	[0.83]
	(0.034)	(0.034)	(0.037)	(0.042)
Constant	0.907***	0.891***	1.010***	0.983***
	[6.92]	[6.81]	[8.22]	[8.30]
	(0.034)	(0.029)	(0.031)	(0.036)
Observations (n)	494	494	494	494
R-squared	0.90	0.90	0.89	0.87

Note: Normalized beta coefficients in brackets. Standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

the inverse of variance for each district's student population. Each of the four tables of regression results presented represents one of the four measures of student achievement regressed over the independent variables for all four years included in the study.

The fixed effect variable (avg_resid) was statistically significant with a positive coefficient for all sixteen regressions. The measure for socioeconomic status (pctenroll) also remained statistically significant with a negative coefficient across all sixteen model iterations. A one percent increase in students eligible for free or reduced meals was associated with anywhere from one-third to three quarters of a percent decrease in the percentage of students achieving state standards on the MEAP depending on the year and subject matter.

All the district resource variables except teacher salaries (avg_t_sal) were statistically significant for all of the regression models. The variable for teacher salaries remained statistically insignificant for all except two regressions. The pupil-teacher ratio (avg_p_tchr) was negative and statistically significant across all sixteen regressions. Its beta coefficient, with only one exception, represented the smallest impact

Table 3
Grade 4 Reading Scores Post-Estimation WLS Regression Results

	School Year			
Variables	**2001–2002**	**2002–2003**	**2003–2004**	**2004–2005**
pctenroll	-0.486***	-0.372***	-0.389***	-0.378***
	[-0.68]	[-0.63]	[-0.70]	[-0.75]
	(0.013)	(0.014)	(0.015)	(0.012)
avg_t_sal	-0.000000261	0.000000919*	-0.000000655	0.000000638
	[-0.013]	[-0.058]	[-0.045]	[-0.049]
	(0.00000051)	(0.00000054)	(0.00000052)	(0.00000041)
avg_p_tchr	-0.00593**	-0.00474***	-0.00527***	-0.00395***
	[-0.10]	[-0.11]	[-0.15]	[-0.12]
	(0.0011)	(0.0012)	(0.0012)	(0.0010)
avg_isal	0.0000475***	0.0000696***	0.0000419***	0.0000421***
	[0.18]	[0.33]	[0.22]	[0.25]
	(0.0000086)	(0.0000087)	(0.0000082)	(0.0000071)
avg_totexp_ntr	-0.0000302***	-0.0000376***	0.0000282***	-0.0000239***
	[-0.22]	[-0.35]	[-0.31]	[-0.30]
	(0.0000035)	(0.0000037)	(0.0000031)	(0.0000028)
avg_resid	0.978***	0.905***	0.799***	0.727***
	[0.60]	[0.67]	[0.63]	[0.62]
	(0.028)	(0.032)	(0.032)	(0.030)
Constant	0.991***	1.030***	1.084***	1.018***
	[8.00]	[10.0]	[11.3]	[11.5]
	(0.027)	(0.027)	(0.027)	(0.025)
Observations (n)	494	494	494	494
R-squared	0.94	0.89	0.87	0.87

Note: Normalized beta coefficients in brackets. Standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

of the school resources measured. The results for the share of the budget spent on instructional salaries per student (avg_isal) remained positive and statistically significant for all sixteen models estimated. with a relatively larger beta than the pupil-teacher ratio.

Total expenditures prior to transportation expense (avg_totexp_ntr) explained as much variation in student achievement as the other school variables with beta coefficients ranging from .15 to .35 standard deviations of the dependent variable. The negative sign on this estimate might be explained by the higher expenditures necessary in urban school districts and the high correlation with instructional salaries.

A primary focus for this study was to analyze the extent to which school district efficiency explained the observed variation in student achievement. The difference in the explanatory power of the specified model after developing a proxy for district efficiency was analyzed by examining the differences in the R^2 results for the regressions without a measure for district fixed effects and the regressions that include these measures.[12]

Table 4
Grade 7 Reading Scores Post-Estimation WLS Regression Results

	School Year			
Variables	**2001–2002**	**2002–2003**	**2003–2004**	**2004–2005**
	(1)	(2)	(3)	(4)
pctenroll	-0.533***	-0.605***	-0.594***	-0.568***
	[-0.73]	[-0.79]	[-0.82]	[-0.91]
	(0.016)	(0.015)	(0.020)	(0.015)
avg_t_sal	-0.000000741	-0.000000445	-0.000000516	-0.000000446
	[-0.036]	[-0.022]	[-0.027]	[-0.027]
	(0.00000063)	(0.00000059)	(0.00000067)	(0.00000052)
avg_p_tchr	-0.00795***	-0.0104***	-0.00482***	-0.00774***
	[-0.13]	[-0.19]	[-0.10]	[-0.19]
	(0.0014)	(0.0013)	(0.0016)	(0.0013)
avg_isal	0.0000486***	0.0000582***	0.0000713***	0.0000512***
	[0.18]	[0.21]	[0.28]	[0.24]
	(0.000011)	(0.0000095)	(0.000011)	(0.0000090)
avg_totexp_ntr	-0.0000356***	-0.0000391***	-0.0000312***	-0.0000313***
	[-0.25]	[-0.28]	[-0.26]	[-0.32]
	(0.0000044)	(0.0000040)	(0.0000040)	(0.0000035)
avg_resid	0.946***	0.889***	0.984***	0.887***
	[0.57]	[0.51]	[0.59]	[0.61]
	(0.034)	(0.035)	(0.041)	(0.038)
Constant	1.037***	1.115***	0.820***	1.063***
	[8.22]	[8.41]	[6.50]	[9.70]
	(0.034)	(0.029)	(0.035)	(0.032)
Observations (n)	494	494	494	494
R-squared	0.92	0.93	0.89	0.91

Note: Normalized beta coefficients in brackets. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 6 shows that after the inclusion of a proxy for district effect the explanatory power of the estimated model increases by fifteen percentage points. The difference in explanatory power remained consistent across all four years in this study. This finding is an important consideration for any measure of school performance or accountability policy. In the absence of a direct measure for district effect, school accountability guidelines may actually only measure student characteristics and the distribution of property wealth given the power of these variables to explain student achievement.[13] The knowledge of what portion of the variation of student achievement is associated with unobserved district effects combined with the estimates that indicate both the direction and magnitude (Tables 2-5) of that effect, offers a good theoretical foundation upon which to build a school district accountability policy.

Table 5
Grade 8 Math Scores Post-Estimation WLS Regression Results

	School Year			
Variables	**2001–2002**	**2002–2003**	**2003–2004**	**2004–2005**
	(1)	(2)	(3)	(4)
pctenroll	-0.634***	-0.668***	-0.641***	-0.672***
	[-0.75]	[-0.76]	[-0.78]	[-0.87]
	(0.017)	(0.020)	(0.021)	(0.017)
avg_t_sal	-0.000000121	-0.000000638	-0.000000426	-0.000000119*
	[-0.0052]	[-0.027]	[-0.020]	[-0.059]
	(0.00000068)	(0.00000075)	(0.00000073)	(0.00000061)
avg_p_tchr	-0.0123***	-0.00937***	-0.0121***	-0.00793***
	[-0.18]	[-0.14]	[-0.23]	[-0.16]
	(0.0015)	(0.0017)	(0.0017)	(0.0015)
avg_isal	0.0000647***	0.0000528***	0.0000569***	0.0000814***
	[0.21]	[0.17]	[0.20]	[0.31]
	(0.000012)	(0.000012)	(0.000012)	(0.000011)
avg_totexp_ntr	-0.0000392***	-0.0000323***	-0.0000441***	-0.0000438***
	[-0.24]	[-0.20]	[-0.33]	[-0.36]
	(0.0000047)	(0.0000051)	(0.0000044)	(0.0000041)
avg_resid	1.039***	1.119***	1.092***	1.082***
	[0.54]	[0.55]	[0.58]	[0.60]
	(0.037)	(0.044)	(0.045)	(0.044)
Constant	1.112***	1.010***	1.132***	0.982***
	[7.67]	[6.60]	[7.96]	[7.23]
	(0.037)	(0.037)	(0.038)	(0.037)
Observations (n)	494	494	494	494
R-squared	0.93	0.91	0.91	0.91

Note: Normalized beta coefficients in brackets. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

In addition, this procedure supplies an objective measure for use in assuring the public and political decisionmakers that funding school districts based on adequacy does not simply reward inefficiency. The objective measurement of district effects provides the means for adjusting legitimate, educationally based, funding differences among districts for the excess costs they encounter due to their own inefficiency.

It is also apparent from Table 6 that district efficiency explains a larger share of the variance in student achievement for the fourth grade than for either the seventh or eighth grades. The fourth grade change is larger for math than for reading. The differences between math and reading narrow in the higher grades. Unobserved effects, for example, school culture, communication, goal orientation, and focus might be more highly associated with early student achievement more than in later grades.

Table 6
Increased Explanatory Power from District Fixed Effects: R-squared Differences

Table 6.1 R-squared for Preliminary Tests on Reading and Math

	School Year				Average
	2001–2002	2002–2003	2003–2004	2004–2005	
read_gr4_sat	0.78	0.70	0.71	0.72	0.73
read_gr7_sat	0.80	0.84	0.75	0.80	0.80
math_gr8_sat	0.82	0.78	0.79	0.80	0.80

Table 6.2 R-squared for Post Estimation Tests on Reading and Math

	School Year				Average
	2001–2002	2002–2003	2003–2004	2004–2005	
math_gr4_sat	0.90	0.90	0.89	0.87	0.89
read_gr4_sat	0.94	0.89	0.87	0.87	0.89
read_gr7_sat	0.92	0.93	0.89	0.91	0.91
math_gr8_sat	0.93	0.91	0.91	0.91	0.92

Table 6.3 R-squared Differences

	School Year				Average
	2001–2002	2002–2003	2003–2004	2004–2005	
math_gr4_sat	0.19	0.20	0.22	0.26	0.22
read_gr4_sat	0.16	0.19	0.16	0.15	0.17
read_gr7_sat	0.12	0.09	0.14	0.11	0.12
math_gr8_sat	0.11	0.13	0.12	0.11	0.12
Average R-squared difference	0.15	0.15	0.16	0.16	0.15

One implication of the disparity of the association of district effect with student achievement depending on grade level comes from separately measuring school accountability or adjusting differential funding by grade. This type of adjustment would be more achievable if the data were available to replicate this study for individual school buildings instead of entire districts.

Conclusions, Implications for Policy, and Further Study

The primary purpose of this study was to test a method for measuring Michigan school district efficiency that could be used to modify a future statewide school funding model based on adequacy. The latter would replace. the current resource equity finance system. Besides production efficiency, the desired indicator also gauges "x-efficiency." This concept evaluates organizational and qualitative attributes of districts not readily observed quantitatively.

The foremost consequence of understanding and measuring the effect of Michigan school district efficiency on student achievement comes from its use to modify Michigan school funding. Redistribution of scarce resources always faces political difficulty and public resistance from those who would bear the burden of providing the benefit to others. Admittedly, this renders a change to an adequacy based Michigan school finance formula politically improbable. However, some future political circumstance, similar to the historical pressure for property tax reform, could materialize and grant unanticipated prominence to this presently dormant policy perspective. Some states have only addressed adequacy of school finance due to actual or threatened litigation, usually arising out of fresh interpretations of their constitutional educational clause. One genuine objection to adequacy comes from the trepidation for rewarding districts experiencing higher costs precipitated at least partially by factors within their control. The reported results from this research lay the groundwork for minimizing this risk. Identifying the variation in student achievement explained by district effects could help limit funding differences to only the higher costs unrelated to district efficiency.

A second policy implication arising from this research comes from its demonstration of the need for better data. Sacrifices were made regarding the unit of analysis and teacher characteristics precipitated by insufficient data. While this comment hardly seems unexpected from a quantitative researcher, it also represents a common problem for educators across the country, including in Michigan. The need for the retention, ready access, and analysis of student data remains acute in most states. Most states do provide paper reports, lagged by several months, to teachers and administrators regarding student test results. Only five states provide advanced information systems for students and teachers plus offer the means to link the two systems.[14]

Michigan should not allow charter schools to avoid reporting crucial data through their use of management companies. An argument based on form that a charter school has no salaries to report cannot be sustained in substance. In essence, the management company pays the salaries as agent for the charter school board of control. Although part of the logic behind charters comes from freedom from bureaucracy, this should not be allowed to interfere with the obligation to demand performance for the investment of tax dollars. This quirk needs to be addressed administratively or by legislation. Neither should Michigan allow bargaining groups or any other special interest to politically prevent the matching of student and teacher performance information.

Previous research has demonstrated that class size reduction has positive effects for student achievement.[15] Some studies reveal diminishing effects for smaller classes.[16] Sometimes they report the positive impact of teacher quality, in addition to the class size measure of teacher quantity.[17] Evidence supporting more cost-effective means of producing positive effects on student achievement may explain the current results controlling for district efficiency.[18] Perhaps improvements in teacher quality can be achieved with aggressive financial incentives to recruit the most qualified and talented people. Organizing learning with higher paid instructional managers supervising larger groups of students assisted by less expensive support staff and technology may leverage teacher resources.

In 2005-2006, Michigan began testing students in contiguous years, as required by the NCLB Act, during grades three through eight for math and English language arts. This will provide the opportunity to measure school performance and efficiency using the student achievement gains accomplished in a single year. It also facilitates the use of lagged student achievement measures as an explanatory variable. This helps account for innate ability and student learning prior to the point of collection for the lagged data. A third enrichment grows out of the ability to measure a single school. This of course assumes that the data elements necessary for school level analysis become available. Student level analysis with linkage to specific classrooms and teachers would provide both increased methodological validity and overall credibility. Direct measures of class size and teacher characteristics also represent improvements. Replication would also be possible using a sample of districts, or even schools, where data was collected directly from the agency and not from the state.

In addition to the need for further quantitative research, only qualitative study will provide the interpretation of what specific attributes differentiate the districts with positive fixed effects from those that prove negative. Well documented, thorough, and repetitive observations and interviews at sites with the highest and lowest magnitude of fixed effect residuals may be necessary.

Guidance for school districts where funding was adjusted downward as a reflection of inefficiency provides a key ingredient to a school funding system based on adequacy. Meaningful direction will depend on the results of the future research, referred to above, that isolates the elements producing both "x-efficiency" and resource efficiency. Clarity regarding these components provides an essential element in creating a financial incentive for improvement. Only cost differences outside of district control should lead to increased funding. Inefficiencies of the district, that increase cost, should not be rewarded.

This study established the relationship between district effects and student achievement. One policy implication includes the adjustment of district funding by some factor representing the district effect on student achievement, in order to avoid rewarding inefficiency. The actual derivation of an adjustment factor for application to Michigan per pupil school funding represents the seeds for future study. This work should address the limitations previously discussed, especially regarding data quality and more complete measures for student achievement. It should also provide detailed guidance regarding the range of choices and qualitative elements of district efficiency.

Regardless of the actual formula chosen, the care, transparency, and thoroughness of the process for its creation and implementation will help determine utility for transitioning to an adequacy-based school finance system in Michigan. The evidence presented here regarding the relationship between district effects and student achievement provides an introductory, but significant, contribution to this Michigan school finance policy arena.

Endnotes

[1] James Phelps and Michael Addonizio, "How Much Do Schools and Districts Matter? A Production Function Approach to School Accountability" *Educational Considerations* 33 (Spring 2006): 51-62, 30.

[2] Henry M Levin, "Raising School Productivity: An X-Efficiency Approach," *The American Economic Review* 16 (June 1997): 303-11.

[3] Harvey Leibenstein, "Allocative Efficiency vs. 'X-Efficiency,'" *The American Economic Review* 56 (June 1966): 392-415.

[4] Charles Cobb and Paul Douglas, "A Theory of Production," *The American Economic Review* 18 (March 1928): 139-65.

[5] Phelps and Addonizio, "How Much Do Schools and Districts Matter?"

[6] The equation attempts to follow that of Phelps and Addonizio as closely as possible given available data. See Phelps and Addonizio, 53.

[7] Charter schools are public schools with a charter from one of the allowable organizations under state law and operate independently from the traditional local public school board in their jurisdiction. Since many of these schools are actually operated by management companies contracted by their board of control, they do not technically have or report any salary information on Bulletin 1014. Based on

the full time equivalency pupil count data maintained by CEPI, the number of charter schools for each of the years in the panel was 185, 185, 192, and 210 respectively.

[8] UCLA Academic Technology Services, "Stata Frequently Asked Questions: What Type of Weights Do SAS, Stata, and SPSS Support?" http://www.ats.ucla.edu/stat/Stata/faq/weights.htm.

[9] Tables are omitted in the interest of brevity but are available from the author.

[10] Phelps and Addonizio, "How Much Do Schools and Districts Matter?"

[11] Ibid.

[12] This technique follows the analysis of Phelps and Addonizio.

[13] Ibid.

[14] David J. Hoff, "Technology Counts: Delving Into Data," *Education Week*, 2006 25 (May 4 2006), 12.

[15] Ronald Ferguson, "Paying for Public Education: New Evidence on How and Why Money Matters," *Harvard Journal on Legislation* 28 (May 1991): 465-98; Larry Hedges, Richard Laine, and Rob Greenwald, "Does Money Matter? A Meta-Analysis of Studies of the Effects of Differential School Inputs and Student Outcomes," *Educational Researcher* 23 (May 1994): 5-14; Barbara Nye, Larry G. Hedges, and Spyros Konstantopoulos, "The Long-Term Effects of Small Class Sizes: A Five-Year Follow-up of the Tennessee Class Size Experiment," *Educational Evaluation and Policy Analysis* 21 (Summer 1999): 127-42; Gary Peevely, Larry Hedges, and Barbara Nye, "The Relationship of Class Size Effects and Teacher Salary," *Journal of Education Finance* 31 (Summer 2005): 101-09.

[16] Ferguson, "Paying for Public Education."

[17] Peevely et al., "The Relationship of Class Size Effects and Teacher Salary."

[18] Lynn Ilon and Anthony H Normore, "Relative Cost Effectiveness of School Resources in Improving Achievement," *Journal of Education Finance* 31 (Winter 2006): 238-54.