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Technical Report: Analysis of Illinois School-Level Value-Added in Academic Year 2014–15

Supplement to "Evaluation of the Illinois Performance Evaluation Reform Act: Final Report"

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Introduction

This report describes the value-added model used by the Value-Added Research Center (VARC) of the Wisconsin Center for Education Research at the University of Wisconsin to measure the productivity or effectiveness of Illinois public schools using Illinois Standards Achievement Test (ISAT) and Partnership for Assessment of Readiness for College and Careers (PARCC) test score data. The report is in three parts. The first part describes the data set used to produce the value-added estimates. The second part describes the model used to estimate value-added for schools in Illinois. Finally, the third part presents some properties of the value-added results.

Conceptually, value-added analysis is the use of statistical techniques to isolate the component of measured student knowledge that is attributable to schools from other factors such as prior knowledge and student characteristics. In practice, value-added models focus on the improvement students make on annual assessments from one year to the next. Value-added models often control for measurable student characteristics using available data such as race, income, and disability to help isolate the impact of schooling. The model uses a large set of student characteristics to identify the extent to which schools contribute to the improvement of student achievement outcomes.

Analysis Data Set

Before estimation can take place, a substantial amount of work is required to assemble the analysis data sets used to produce the value-added estimates. A separate analysis data set is produced for each grade, subject, and test. In total, 10 analysis data sets are produced, covering grades 4 through 8 for PARCC reading and mathematics in 2014–15.

Each analysis data set includes students who have a posttest in the grade and subject being considered, pretests in both reading and mathematics, and were tested in consecutive grades. We exclude students that are missing any demographic data included in the model. We also exclude students who have out-of-range test scores on the 2014 ISAT pretest, have inconsistent school or district IDs, or are missing from the enrollment data.

Student-Level Variables

Posttest and Pretest Variables

The test scores used are from 2013–14 ISAT and 2014–15 PARCC assessments. The value-added system produces school-level measures for grades 4 through 8 in reading and mathematics based on PARCC data. Value-added in reading and mathematics is defined by the system's usage of a reading or mathematics test as a posttest. All PARCC value-added models include pretests in both reading and mathematics.

Standard Errors of Measurement of Pretest Variables

The standard errors of measurement (SEM) of mathematics and reading scores are set to conditional SEMs posted for ISAT on the Illinois State Board of Education (ISBE) website. The standard errors of measurement are used for a correction for measurement error in the pretests.

Gender, Race/Ethnicity, Economic Disadvantage, and Homelessness

Gender, race/ethnicity, economic disadvantage, and homelessness are drawn from the student enrollment dataset. In the analysis data set, students are assigned the gender, race/ethnicity, low-income status, and homeless status reported in the posttest year. Gender categories are male and female. Race categories are American Indian/Alaska Native, Asian/Native Hawaiian/Pacific Islander, Black/African American, Hispanic/Latino, White, and other/multi-racial. The analysis uses two indicators for economically disadvantaged students and for homeless students.

English Learner

English learner (EL) data were obtained from ACCESS, an English language proficiency test administered in Illinois that is designed to measure English language learners' social and academic proficiency in English. There are three indicators for EL status in the data, based on students' prior-year ACCESS composite score: Less than 3, 3 to less than 4, and 4 and above.

Disability

The analysis includes a single indicator for students with disabilities according to whether they have an Individualized Education Program (IEP).

Mobility

Student mobility is determined by calculating the number of times a student changed schools in the enrollment files. A single indicator is included to signify that the student changed schools at least once during the 2014–15 school year (from the beginning of the school year to the end of the spring testing window).

School Enrollment

Students are assigned to one or more schools using the Illinois State Board of Education (ISBE) school enrollment data. The relative weight or dosage attributed to a given school is determined by the proportion of the school year that the student was enrolled at that school. If students are not fully claimed in the school enrollment data, the student's unclaimed portion is assigned to a placeholder school.

Descriptive Statistics of Analysis Samples

The following tables describe the sample used for the 2015 year for PARCC mathematics and reading:

Table 1. Sample characteristics: PARCC mathematics

Sample characteristic	Grade				
	4	5	6	7	8
Number of students	128,715	131,738	13,0638	129,234	130,742
Posttest mean	733.48	732.89	733.12	734.43	734.36
Mathematics pretest mean	219.41	233.60	248.28	256.17	264.07
Reading pretest mean	208.50	220.02	231.91	240.67	243.43
Posttest standard deviation	30.22	29.46	29.00	26.91	36.80
Mathematics pretest standard deviation	30.99	28.51	31.72	31.86	29.09
Reading pretest standard deviation	30.03	27.71	26.72	23.75	25.73
Proportion in special education	0.124	0.123	0.121	0.120	0.115
Proportion with limited English proficiency (LEP)	0.095	0.056	0.042	0.042	0.047
Proportion with free/reduced-price lunch (FRPL)	0.536	0.526	0.521	0.509	0.503
Proportion homeless	0.014	0.014	0.014	0.013	0.013
Proportion female	0.490	0.491	0.489	0.491	0.492
Proportion African-American	0.152	0.153	0.154	0.153	0.156
Proportion Asian	0.049	0.049	0.048	0.047	0.047
Proportion Native American	0.003	0.002	0.003	0.003	0.003
Proportion Hispanic	0.265	0.260	0.257	0.251	0.248
Proportion other race/ethnicity	0.032	0.032	0.030	0.029	0.028
Proportion with mobility	0.004	0.004	0.005	0.003	0.004
Proportion with ACCESS literacy score less than 3	0.008	0.005	0.005	0.008	0.010
Proportion with ACCESS literacy at least 3, less than 4	0.028	0.017	0.017	0.026	0.028
Proportion with ACCESS literacy at least 4	0.132	0.051	0.028	0.009	0.010

Table 2. Sample Characteristics: PARCC reading

Sample characteristic	Grade				
	4	5	6	7	8
Number of students	128,570	131,559	130,614	129,238	130,972
Posttest mean	741.86	740.78	738.94	740.45	741.11
Mathematics pretest mean	208.52	220.03	231.91	240.69	243.42
Reading pretest mean	219.42	233.61	248.27	256.19	264.07
Posttest standard deviation	32.35	31.00	30.14	34.79	35.39
Mathematics pretest standard deviation	30.02	27.71	26.72	23.74	25.73
Reading pretest standard deviation	30.99	28.51	31.72	31.86	29.09
Proportion in special education	0.124	0.123	0.121	0.120	0.115
Proportion with limited English proficiency (LEP)	0.095	0.056	0.042	0.042	0.047
Proportion with free/reduced-price lunch (FRPL)	0.536	0.525	0.521	0.509	0.503
Proportion homeless	0.014	0.014	0.014	0.013	0.013
Proportion female	0.490	0.491	0.489	0.491	0.492
Proportion African-American	0.152	0.153	0.154	0.154	0.157
Proportion Asian	0.049	0.049	0.048	0.047	0.047
Proportion Native American	0.003	0.002	0.003	0.003	0.003
Proportion Hispanic	0.265	0.259	0.257	0.251	0.248
Proportion other race/ethnicity	0.032	0.032	0.030	0.029	0.028
Proportion with mobility	0.003	0.004	0.005	0.003	0.004
Proportion with ACCESS literacy score less than 3	0.008	0.005	0.005	0.008	0.010
Proportion with ACCESS literacy at least 3, less than 4	0.028	0.017	0.017	0.026	0.028
Proportion with ACCESS literacy at least 4	0.131	0.051	0.028	0.009	0.010

Value-Added Model

For the Illinois school-level model, value-added is measured in mathematics and reading in grades 4 through 8 for PARCC. Schools are assigned single-year value-added measures that reflect student growth in 2014–15 for PARCC.

The Model, in Brief

The value-added model is defined by four equations: a "best linear predictor" value-added model defined in terms of true student post and prior achievement and three measurement error models for observed post and prior achievement:

$$\text{Student achievement: } y_{1i} = \zeta + \lambda y_{0i} + \lambda^{alt} y_{0i}^{alt} + \beta' X_i + \alpha' S_i + e_i \quad (1)$$

$$\text{Posttest measurement error: } Y_{1i} = y_{1i} + v_{1i} \quad (2)$$

$$\text{Same-subject pretest measurement error: } Y_{0i} = y_{0i} + v_{0i} \quad (3)$$

$$\text{Other-subject pretest measurement error: } Y_{0i}^{alt} = y_{0i}^{alt} + v_{0i}^{alt} \quad (4)$$

where:

- y_{1i} is true post achievement;
- y_{0i} and y_{0i}^{alt} are true prior achievement in the same subject and in the other subject (mathematics in the reading model, reading in the mathematics model), with slope parameters λ and λ^{alt};
- X_i is a vector of characteristics of student i, with slope parameter vector β;
- S_i is a vector of indicators for school;
- α is a vector of school effects;
- e_i is the error in predicting post achievement given the explanatory variables included in the model;
- Y_{1i} is measured post achievement;
- v_{1i} is measurement error in post achievement;
- Y_{0i} and Y_{0i}^{alt} are measured prior achievement; and
- v_{0i} and v_{0i}^{alt} are measurement error in prior achievement.

Substituting the measurement error equations (2), (3), and (4) into the student achievement equation (1) yields an equation defined in terms of measured student achievement:

$$\text{Measured achievement: } Y_{1i} = \zeta + \lambda Y_{0i} + \lambda^{alt} Y_{0i}^{alt} + \beta X_i + \alpha' S_i + \varepsilon_i \qquad (5)$$

where the error term ε_i includes both the original error component and the measurement error components:

$$\text{Error in measured achievement: } \varepsilon_i = e_i + v_{1i} - \lambda v_{0i} - \lambda^{alt} v_{0i}^{alt} \qquad (6)$$

Estimating the measured student achievement equation (5) without controlling for pretest measurement error yields biased estimates of all parameters, including the value-added effects. This bias stems from the fact that measurement error in prior achievement causes the error term (6), which includes the measurement error components v_{0i} and v_{0i}^{alt}, to be correlated with measured prior achievement. The desired parameters, as defined in equation (1), can be estimated consistently if external information is available on the variance of measurement error for prior achievement; approaches for consistent estimation in the presence of measurement error are described in detail in *Measurement Error Models* (Fuller, 1987). Information about the variance of test measurement error is reported in the technical manual for the 2013–14 ISAT assessment.

A shrinkage approach is used to ensure that schools with fewer students are not overrepresented among the highest- and lowest-value-added cases due to randomness. The approach, Empirical Bayes shrinkage, is described in *Small Area Estimation* (Rao, 2003).

The Variables in the Model

In addition to posttest and pretest scores, the student-level variables included in the model (the *X* variables in equation (1) are gender, race/ethnicity, English learner status, economic disadvantage, disability, homelessness, and mobility.

Value-Added Regression

The value-added model is run using a least-squares regression approach that corrects for measurement error in the pretest variables. It estimates the coefficients λ, β, and α by regressing posttest on same-

subject pretest, other-subject pretest, other student-level variables, and a full set of school fixed effects. This can be expressed mathematically using equation (5) above:

$$\text{Measured achievement: } Y_{1i} = \zeta + \lambda Y_{0i} + \lambda^{alt} Y_{0i}^{alt} + \beta' X_i + \alpha' S_i + \varepsilon_i \qquad (5)$$

This regression is estimated using an approach that accounts for measurement error in the pretests Y_{0i} and Y_{0i}^{alt}. Recall from equation (6) above that the measurement error components of Y_{0i} and Y_{0i}^{alt}, v_{0i} and v_{0i}^{alt}, are part of the error term ε_i. As a result, estimating the regression using ordinary least squares will lead to biased estimates. The regression approach used accounts for measurement error by removing the variance in the pretests that is attributable to measurement error. To illustrate the measurement error corrected regression, re-cast the above value-added regression equation into vector form:

$$Y_t = Y_{t-1}\lambda + W\delta + \varepsilon$$

where Y_t is an N × 1 vector of post-test scores, Y_{t-1} is an N × 2 vector of same-subject and other-subject pre-test scores Y_{t-1} and Y_{t-1}^{alt}, λ is a 2 × 1 vector made up of λ and λ^{alt}, W is an N × K vector of the X demographic variables, δ is a K × 1 vector of the β and α^* coefficients, and ε is an N × 1 vector of error terms. The biased ordinary-least-squares estimates of the coefficients in λ and δ are equal to:

$$\begin{bmatrix} \hat{\lambda}_{OLS} \\ \hat{\delta}_{OLS} \end{bmatrix} = \begin{bmatrix} Y'_{t-1}Y_{t-1} & Y'_{t-1}W \\ W'Y_{t-1} & W'W \end{bmatrix}^{-1} \begin{bmatrix} Y'_{t-1}Y_t \\ W'Y_t \end{bmatrix}$$

The measurement-error-corrected estimates of the coefficients in λ and δ are equal to:

$$\begin{bmatrix} \hat{\lambda}_{EIV} \\ \hat{\delta}_{EIV} \end{bmatrix} = \begin{bmatrix} Y'_{t-1}Y_{t-1} - \sum_i^N sem_{it-1} & Y'_{t-1}W \\ W'Y_{t-1} & W'W \end{bmatrix}^{-1} \begin{bmatrix} Y'_{t-1}Y_t \\ W'Y_t \end{bmatrix}$$

where sem_{it-1} is a 2 × 2 variance-covariance matrix of the errors of measurement of Y_{it-1} and Y_{it-1}^{alt} for student i. This model is described in section 2.2 of *Measurement Error Models* (Fuller, 1987).

Aggregation to Multiple-Grade Value-Added

The value-added regression to obtain unshrunk school value-added is performed separately for each combination of grade, subject, test, and year. For schools that have results for more than one grade level, these estimates are averaged across grades, using the number of students attributed to the school in full-year equivalents as weights, to produce unshrunk multiple-grade value-added estimates. Before aggregation, value-added measures by grade are normalized in order to be on similar scales (i.e., with a mean of 0 and a true standard deviation of (1) across grades. This normalization is made by dividing the measures by an estimate of the standard deviation of value-added within grade.

Shrinkage of Value-Added

At all levels, the unshrunk value-added estimates are shrunk using an Empirical Bayes univariate shrinkage technique described in Rao (2003).This is estimated by multiplying each value-added measure by its reliability:

$$\alpha_{\text{shrunk}} = (\omega^2 / (\omega^2 + \sigma^2))\alpha_{\text{unshrunk}}$$

where α_{unshrunk} is an unshrunk value-added estimate for a given school; σ^2 is the squared standard error of α_{unshrunk}; and ω^2 is the variance of value-added across schools within subject, test, and grade(s). The standard error of the shrunk value-added estimate is equal to

$$\text{s.e. } (\alpha_{\text{shrunk}}) = \text{sqrt } [\omega^2\sigma^2 / (\omega^2 + \sigma^2)]$$

The variance measure ω^2 is estimated by computing the variance of the unshrunk value-added estimates, then subtracting from that the average squared standard error of the unshrunk value-added estimates. This variance measure is an estimate of the variance of the underlying value-added measures, excluding variance due to randomness in the value-added estimates. The square root of this variance measure is also used for normalizing value-added measures by grade before aggregation to multiple-grade measures.

Properties of the Value-Added Results

Coefficients on Student-Level Variables in the Model

The coefficients estimated in the value-added model are presented in Tables 3 and 4 below. To interpret these coefficients, note that both pretest and posttest are measured using standardized scores; therefore, all coefficients are measured in the posttest standard deviation scale. For example, note that the coefficient on female gender is 0.01 in grade 4 mathematics. This implies that female students improved 0.01 standard deviations more on the grade 4 mathematics test from spring to spring than otherwise similar male students.

It is important to keep in mind the standard errors (SE) of the coefficients when interpreting them. A span of 1.96 standard errors in both the positive and negative directions provides a 95 percent confidence range for a coefficient. For example, note that the coefficient on free/reduced-price lunch in grade 4 mathematics is -.059. The standard error on this coefficient is 0.004. This means that, while our best estimate of the effect of economic disadvantage on student growth is -0.059 standard deviations, a 95 percent confidence range for the effect estimate would range from -0.067 to -0.051 standard deviations.

Table 3. Coefficients on student-level variables: 2014–15 PARCC mathematics

	Grade									
	4		5		6		7		8	
Variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Mathematics pretest	0.807	0.004	0.968	0.005	0.805	0.004	0.797	0.005	0.816	0.005
Reading pretest	0.080	0.004	-0.051	0.005	0.118	0.004	0.114	0.005	0.085	0.005
Special education	-0.053	0.005	0.078	0.005	-0.034	0.005	-0.104	0.005	0.007	0.005
Limited English proficiency (LEP)	0.015	0.008	0.041	0.013	-0.032	0.015	0.005	0.025	0.009	0.027
Free/reduced-price lunch (FRPL)	-0.059	0.004	-0.042	0.004	-0.048	0.004	-0.030	0.004	-0.033	0.004
Homeless	-0.023	0.013	-0.014	0.013	0.005	0.012	-0.015	0.013	-0.014	0.013
Female	0.013	0.003	0.119	0.003	0.034	0.003	0.001	0.003	0.041	0.003
African-American	-0.059	0.007	0.010	0.007	-0.074	0.006	-0.043	0.006	-0.051	0.006
Asian	0.108	0.007	0.158	0.008	0.081	0.007	0.057	0.007	0.079	0.007
Native American	-0.028	0.028	0.042	0.030	-0.042	0.026	-0.026	0.026	-0.012	0.027
Hispanic	-0.011	0.005	0.016	0.005	-0.007	0.005	-0.009	0.005	-0.017	0.005
Other race/ethnicity	-0.014	0.009	0.018	0.009	-0.018	0.008	0.014	0.008	-0.021	0.009
Mobility	-0.061	0.025	0.033	0.026	-0.029	0.026	-0.067	0.027	-0.106	0.029
ACCESS literacy score less than 3	0.042	0.019	0.226	0.025	0.017	0.025	-0.007	0.029	0.069	0.031
ACCESS literacy at least 3, less than 4	0.005	0.012	0.093	0.017	0.014	0.019	-0.024	0.026	0.030	0.029
ACCESS literacy at least 4	-0.029	0.006	-0.016	0.011	-0.002	0.013	0.034	0.024	0.023	0.026

Table 4. Coefficients on student-level variables: 2014–15 PARCC reading

Variable	Grade									
	4		5		6		7		8	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Mathematics pretest	0.802	0.005	0.775	0.005	0.813	0.005	0.916	0.006	0.860	0.005
Reading pretest	0.078	0.004	0.099	0.005	0.061	0.004	-0.002	0.005	0.017	0.005
Special education	-0.035	0.005	-0.064	0.005	-0.097	0.005	-0.023	0.006	-0.030	0.006
Limited English proficiency (LEP)	0.012	0.008	-0.014	0.013	-0.043	0.017	-0.037	0.028	-0.046	0.030
Free/reduced-price lunch (FRPL)	-0.046	0.004	-0.052	0.004	-0.043	0.004	-0.017	0.004	-0.041	0.004
Homeless	-0.006	0.014	-0.015	0.014	-0.022	0.013	-0.023	0.014	-0.034	0.014
Female	0.147	0.003	0.150	0.003	0.201	0.003	0.216	0.003	0.199	0.003
African-American	-0.033	0.007	0.000	0.007	-0.045	0.007	-0.058	0.007	-0.057	0.007
Asian	0.078	0.008	0.097	0.008	0.074	0.008	0.103	0.008	0.093	0.008
Native American	-0.038	0.029	0.016	0.031	0.035	0.029	0.019	0.030	-0.039	0.030
Hispanic	0.016	0.006	0.014	0.005	0.010	0.005	0.002	0.005	-0.002	0.005
Other race/ethnicity	0.009	0.009	0.007	0.009	0.009	0.009	0.011	0.009	-0.007	0.010
Mobility	-0.025	0.027	-0.031	0.028	-0.049	0.030	-0.065	0.031	-0.099	0.032
ACCESS literacy score less than 3	-0.105	0.020	0.006	0.026	0.026	0.028	0.172	0.033	0.052	0.034
ACCESS literacy at least 3, less than 4	-0.024	0.013	0.011	0.018	0.003	0.021	0.045	0.030	0.029	0.031
ACCESS literacy at least 4	0.004	0.007	-0.034	0.011	-0.021	0.014	0.091	0.027	0.052	0.029

Correlation With Average Prior Proficiency

Results show a very low correlation between average prior proficiency—a measure of average performance in the previous year—and value-added. In general, schools were not more or less likely to have a low value-added score than a high score if their students began the year with low pretest scores rather than high scores.

Table 5. Correlations between prior attainment and value-added: 2014–15 PARCC

	Grade					
Subject	**4**	**5**	**6**	**7**	**8**	**School**
Reading	0.04	0.08	0.09	0.09	0.12	0.15
Mathematics	0.01	-0.01	-0.06	0.03	0.07	0.09

Correlation Between Mathematics and Reading Value-Added

There were also substantive positive correlations between mathematics and reading value-added within each school. Schools that were high value-added in mathematics were also more often than not also high value-added in reading.

Table 6. Correlations between mathematics and reading value-added

	Grade					
Subject	**4**	**5**	**6**	**7**	**8**	**School**
Correlation between mathematics and reading value-added	0.58	0.48	0.43	0.52	0.61	0.59

References

Fuller, W. (1987). *Measurement Error Models.* Hoboken, NJ: Wiley.

Rao, J. N. K (2003). *Small Area Estimation.* Hoboken, NJ: Wiley.