

ABSTRACT

I. Conceptual Framework

Statistical Model.

$$j_{it} = \beta_j X_{it} + \alpha_{jt} + \epsilon_{it}$$

$$X_{it} = \beta_X X_{it} + \alpha_{jt} + \epsilon_{it}$$

$$Y_i = \beta_Y X_{it}$$

$$Y_{it} = Y_i - \beta^Y X_{it}$$

$$Y_{it}$$

t

$$Y_{it} = a + \beta_j m_{jt} + \epsilon_{it}$$

$$m_{jt} = \beta_j$$

j

Empirical Implementation. it m_{jt} g

A. School District Data

Test Scores.

Sample Restrictions.

Total Income.

College Attendance.

C. Summary Statistics

D. Cross-Sectional Correlations

\mathbf{X}_{it}

III. Research Design 1: Cross-Class Comparisons

$$Y_{it} = \mathbf{X}_{it} \hat{\mathbf{m}}_{jt} + \beta^Y Y_{it}$$

\hat{m}

$$= p$$

×

$$\frac{\times}{\quad} =$$

$$\begin{aligned}
 & \widehat{m}_{jt}^{\{t-\}} \\
 & j \quad t- \\
 & \widehat{m}_{jt}^{\{t-\}} \\
 & s \quad g \\
 & Q_{sgt} \\
 & Q_{sgt} = Q_{sgt} - Q_{sgt-} \\
 & g \quad s \\
 & t \quad t- \\
 & Y_{sgt} \\
 & Q_{sgt} \\
 & Y_{sgt} \\
 & Q_{sgt}
 \end{aligned}$$

$$Y_{sgt} = + Q_{sgt} + \text{sgt}$$

Assumption 3 [Teacher Switching as a Q329z3088 (e) 0.188 (ria) -0435 h)

larger

$b =$

Drift in Quality over Subsequent School Years.

$$\begin{aligned}
 & \hat{m}_{j, n+m} \quad n + \\
 & \quad n + m \\
 & G_m n = -E \left[m_{j, n+m} \mid \hat{m}_{j, n+m}, F_{\hat{m}_{j, n+m}}^- \right] \times \quad \times b \\
 & E \left[m_{j, n+m} \mid \hat{m}_{j, n+m}, F_{\hat{m}_{j, n+m}}^- \right] \quad n + m \\
 & \quad n + \\
 & G_C m = \times G_m \quad m \\
 & \quad \hat{m}_j
 \end{aligned}$$

Costs of Teacher Selection.

Retention of High VA Teachers.

$$\times \quad \times \quad \times E \left[m_{j\ n+} \mid \hat{m}_{j\ n+} = F_{\hat{m}_j}^- \right]$$

VII. Conclusion

Aaronson, Daniel, Lisa Barrow, and William Sander.

Deming, David.

American Economic Journal: Applied Economics

District of Columbia Public Schools.

Dynarski, Susan, Joshua M. Hyman, and Diane Whitmore Schanzenbach.

Journal of Policy Analysis and Management

Gordon, Robert, Thomas J. Kane, and Douglas O. Staiger.

2013. on.30 10.909 19 (46-46)

Gunderson, Morley K. and Philip Oreopoulos.

International Encyclopedia of Education, 3rd edition

Haider, Steven, and Gary Solon.

American Economic Review

Hanushek, Eric A.

Journal of Human Capital

American Economic Review Papers and Proceedings

Hanushek, Eric A., and Steven G. Rivkin.

American Economic Review Papers and Proceedings

Hanushek, Eric A.

Creating a New Teaching Profession

Jacob, Brian A.

Journal of Public Economics

Todd, Petra E. and Kenneth I. Wolpin.

The Economic Journal

Online Appendix A: Structural Interpretation of Reduced-Form Parameters

Dynamic Model: Setup

h Y_i

$$Y_i = Y X_{it} + \sum_{g=h}^G g j t_i g + Y_{it}$$

g

g

Y_{it}

it

Y_{it}

jt

jt

$$j = \sum_{g=h}^G g j t_i g$$

College Quality Index.

$$Y_{ig} = Co(m_{jg}, m_{jg}) / Var(m_{jg})$$

$$g = \frac{Co(\sum_{g=1}^m \tilde{g} m_{jg} + m_{ig} m_{jg})}{Var(m_{jg})} = \sum_{g=1}^m \tilde{g} g$$

$$Co(m_{jg}, m_{jg}) = g \cdot g$$

$$G = \quad \times \quad \times \quad \times \quad =$$

Deselection on Estimated VA: Monte-Carlo Simulations.

$$A \quad \bar{A}_j^{-t}$$

$$A \quad A_s = A \quad S \quad A_s$$

$$A_s = A \quad S \quad A$$

+

$$\hat{m}_{j_{n+}} \quad n \quad N \quad A$$

$$n + \quad \hat{m}_{j_{n+}}$$

A

n

TABLE 2
Impacts of Teacher Value-Added on College Attendance

Dep. Var.:	College at Age 20	College at Age 20	College at Age 20	College Quality at Age 20	College Quality at Age 20	College Quality at Age 20	High Quality College	4 or More Years of College, Ages 18-22
	(%)	(%)	(%)	(\$)	(\$)	(\$)	(%)	(%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Teacher VA	0.82 (0.07)	0.71 (0.06)	0.74 (0.09)	298.63 (20.74)	265.82 (18.31)	266.17 (26.03)	0.72 (0.05)	0.79 (0.08)
Mean of Dep. Var.	37.22	37.22	37.09	26,837	26,837	26,798	13.41	24.59
Baseline Controls	X	X	X	X	X	X	X	X
Parent Chars. Controls		X			X			
Lagged Score Controls			X			X		
Observations	4,170,905	4,170,905	3,130,855	4,167,571	4,167,571	3,128,478	4,167,571	3,030,878

Each column reports coefficients from an OLS regression, with standard errors clustered by school-cohort in parentheses. The regressions are estimated on the linked analysis sample (as described in the notes to Table 1). Teacher value-added is estimated using data from classes taught by a teacher in other years, following the procedure described in Section III.A. The dependent variable in Columns 1-3 is an indicator for college attendance at age 20. The dependent variable in Columns 4-6 is the earnings-based index of college quality. See notes to Table 1 and Section II for more details on the construction of these variables. The dependent variable in Column 7 is an indicator for attending a high-quality college, defined as quality greater than the median college quality among those attending college, which is \$43,914. The dependent variable in Column 8 is an indicator for attending four or more years of college between the ages of 18 and 22. All columns control for the baseline class-level control vector, which includes: class size and class-type indicators; cubics in class and school-grade means of lagged own- and cross-subject scores, interacted with grade level; class and school-year means of student-level characteristics including ethnicity, gender, age, lagged suspensions and absences, and indicators for grade repetition, special education, free or reduced-price lunch, and limited English; and

Dep. Var.:	Earnings at Age 28	Earnings at Age 28	Earnings at Age 28	Working at Age 28	Total Income at Age 28	Wage Growth Ages 22-28
	(\$)	(\$)	(\$)	(%)	(\$)	(\$)
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher VA	349.84	285.55	308.98	0.38	353.83	286.20

TABLE 4
Impacts of Teacher Value-Added on Other Outcomes

Dep. Var.:	Teenage Birth	Percent College Grad in ZIP at Age 28	Have 401(k) at Age 28
	(%) (1)	(%) (2)	(%) (3)
Teacher VA	-0.61 (0.06)	0.25 (0.04)	0.55 (0.16)
Mean of Dep. Var.	13.24	13.81	19.81
Baseline Controls	X	X	X
Observations	2,110,402	468,021	650,965

Each column reports coefficients from an OLS regression, with standard

	Dep. Var.:				Pred. Coll. Attendance (%)
	(1)	(2)	(3)	(4)	(5)
Teacher VA	0.86 (0.23)	0.73 (0.25)	0.67 (0.26)	1.20 (0.58)	0.02 (0.06)
Year FE	X				
School x Year FE		X	X	X	X
Lagged Score Controls			X		
Lead and Lag Changes in Teacher VA			X		
Number of School x Grade x Subject x Year Cells	33,167	33,167	26,857	8,711	33,167
Sample:	Full Sample	Full Sample	Full Sample	No Imputed Scores	Full Sample

	Dep. Var.:				Pred. Coll. Quality (\$)
	(1)	(2)	(3)	(4)	(5)
Teacher VA	197.64 (60.27)	156.64 (63.93)	176.51 (64.94)	334.52 (166.85)	2.53 (18.30)
Year FE	X				
School x Year FE		X	X	X	X
Lagged Score Controls			X		
Lead and Lag Changes in Teacher VA			X		
Number of School x Grade x Subject x Year Cells	33,167	33,167	26,857	8,711	33,167
Sample:	Full Sample	Full Sample	Full Sample	No Imputed Scores	Full Sample

APPENDIX TABLE 1
Structure of Linked Analysis Dataset

Student	Subject	Year	Grade	Class	Teacher	Test Score	Matched to Tax Data?	Earnings at Age 28
Bob	Math	1992	4	1	Jones	0.5	1	\$35K
Bob	English	1992	4	1	Jones	-0.3	1	\$35K
Bob	Math	1993	5	2	Smith	0.9	1	\$35K
Bob	English	1993	5	2	Smith	0.1	1	\$35K
Bob	Math	1994	6	3	Harris	1.5	1	\$35K
Bob	English	1994	6	4	Adams	0.5	1	\$35K
Nancy	Math	2002	3	5	Daniels	0.4	0	.
Nancy	English	2002	3	5	Daniels	0.2	0	.
Nancy	Math	2003	4	6	Jones	-0.1	0	.
Nancy	English	2003	4	6	Jones	0.1	0	.

This table illustrates the structure of the linked analysis sample which combines information from the school district database and the tax data. There is one row for each student-subject-school year. Individuals who were not linked to the tax data have missing data on adult outcomes and parent characteristics. The values in this table are not real data and are for illustrative purposes only.

APPENDIX TABLE 4
Cross-Sectional Correlations Between Test Scores and Earnings by Age

Age:	Dependent Variable: Earnings (\$)								
	20 (1)	21 (2)	22 (3)	23 (4)	24 (5)	25 (6)	26 (7)	27 (8)	28 (9)
No Controls	889 (20)	1,098 (25)	1,864 (28)	3,592 (34)	4,705 (39)	5,624 (44)	6,522 (48)	7,162 (51)	7,768 (54)
With Controls	392 (64)	503 (79)	726 (91)	1,372 (110)	1,759 (125)	1,971 (139)	2,183 (152)	2,497 (161)	2,784 (171)
Mean Earnings	6,484	8,046	9,559	11,777	14,004	16,141	18,229	19,834	21,320
Pct. Effect (with controls)	6.1%	6.2%	7.6%	11.6%	12.6%	12.2%	12.0%	12.6%	13.1%

Each cell in the first two rows reports coefficients from a separate OLS regression of earnings at a given age on test scores measured in standard deviation units, with standard errors in parentheses. See notes to Table 1 for our definition of earnings. We restrict this table to students born in cohorts 1979 and 1980, so that regressions are estimated on a constant subsample of the linked analysis sample. There is one observation for each student-subject-school year, and we pool all subjects and grades in estimating these regressions. The first row includes no controls; the second includes the full vector of student- and class-level controls used to estimate the baseline value-added model described in Section III.A as well as teacher fixed effects. Means of earnings for the estimation sample with controls are shown in the third row. The last row divides the coef152955(h)0.de

APPENDIX TABLE 5
Heterogeneity in Cross-Sectional Correlations Across Demographic Groups

Dependent Variable:	Earnings at	College at	College Quality	Teenage
	Age 28	at Age 20	Age 20	Birth
	(\$)	(%)	(\$)	(%)
	(1)	(2)	(3)	(4)
Male	2,408 (88) [22,179]	5.36 (0.06) [34.24]	1,976 (16) [26,205]	n/a
Female	2,735 (80) [21,078]	5.74 (0.06) [41.07]	2,262 (17) [27,695]	-1.58 (0.05) [13.25]
Non-minority	2,492 (139) [31,587]	5.11 (0.08) [59.67]	2,929 (27) [34,615]	-0.72 (0.04) [2.82]
Minority	2,622 (62) [17,644]	5.65 (0.05) [28.98]	1,734 (12) [23,917]	-1.96 (0.06) [17.20]
Low Parent Inc.	2,674 (85) [18,521]	5.14 (0.06) [26.91]	1,653 (15) [23,824]	-1.72 (0.07) [16.67]
High Parent Inc.	2,573 (92) [26,402]	5.73 (0.06) [49.92]	2,539 (18) [30,420]	-1.29 (0.06) [9.21]

Each column reports coefficients from an OLS regression, with standard errors in parentheses and the mean of the dependent variable in the estimation sample in brackets. These regressions replicate the second row (full sample, with controls and teacher fixed effects) of estimates in Columns 1-4 of Appendix Table 3, splitting the sample based on student demographic characteristics. The demographic groups are defined in exactly the same way as in Panel A of Table 6. We split rows 1 and 2 by the student's gender. We split the sample in rows 3 and 4 based on whether a student belongs to an ethnic minority (black or hispanic). We split the sample in rows 5 and 6 based on whether a student's parental income is higher or lower than median in the sample, which is \$31,905.

APPENDIX TABLE 6

Dep. Variable:	Earnings at Age 28	College at Age 20	College Quality at Age 20	Earnings at Age 28	College at Age 20	College Quality at Age 20
	(\$) (1)	(%) (2)	(\$) (3)	(\$) (4)	(%) (5)	(\$) (6)
Grade 4	7,561 (57)	18.29 (0.05)	6,378 (13)	2,970 (122)	6.78 (0.09)	2,542 (23)
Grade 5	7,747 (50)	18.27 (0.05)	6,408 (13)	2,711 (108)	5.28 (0.08)	2,049 (23)
Grade 6	7,524 (51)	17.95 (0.05)	6,225 (14)	2,395 (140)	4.92 (0.10)	1,899 (27)
Grade 7	7,891 (54)	18.23 (0.05)	6,197 (14)	2,429 (198)	4.48 (0.11)	1,689 (29)
Grade 8	7,795 (48)	19.10 (0.05)	6,596 (13)	2,113 (141)	5.43 (0.11)	2,106 (28)

APPENDIX TABLE 7

Robustness of Baseline Results to Student-Level Controls, Clustering, and Missing Data

Dep. Var.:	College at Age 20 (%) (1)	College Quality at Age 20 (\$) (2)	Earnings at Age 28 (\$) (3)
Teacher VA, with baseline controls	0.825 (0.072)	299 (21)	350 (92)
Observations	4,170,905	4,167,571	650,965
Teacher VA, with additional individual controls	0.873 (0.072)	312 (21)	357 (90)
Observations	4,170,905	4,167,571	650,965
Teacher VA, school clustered	0.825 (0.115)	299 (36)	350 (118)
Observations	4,170,905	4,167,571	650,965
Teacher VA, cells > 95% VA coverage	0.819 (0.090)	277 (26)	455 (202)
Observations	2,238,143	2,236,354	363,392
Teacher VA, cells > median match rate	0.912 (0.094)	345 (28)	563 (203)
Observations	2,764,738	2,762,388	278,119

5% 4% 3% 2% **1%** 0%
(1) (2) (3) (4) (5) (6) (7) (8)

Test Score

Dependent Variable:

	Age: 18	19	20	21	22	23	24	25	26	27	28
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Teacher Value-Added	0.61 (0.06)	0.81 (0.07)	0.82 (0.07)	0.98 (0.08)	0.71 (0.07)	0.44 (0.07)	0.58 (0.07)	0.46 (0.08)	0.50 (0.07)	0.46 (0.09)	-0.01 (0.11)
Mean Attendance Rate	29.4	36.8	37.2	35.7	32.2	24.4	20.31	17.3	15.7	13.9	12.3

Dependent Variable:

	Age:	20	21	22	23	24	25	26	27	28
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Teacher Value-Added		-32 (11)	-35 (14)	-18 (18)	44 (25)	74 (32)	141 (44)	230 (47)	254 (63)	350 (92)
Mean Earnings		5,696	735(,)-0.168573(6)	0.151-1135(e)	0.15251861(g)	0.151	70.84(735.154041(6)			

APPENDIX TABLE 10
Impacts of Teacher Value-Added on Current and Future Test Scores

Dep. Var.:	t (1)	t+1 (2)	t+2 (3)	t+3 (4)	t+4 (5)
Teacher VA	0.993 (0.006)	0.533 (0.007)	0.362 (0.007)	0.255 (0.008)	0.221 (0.012)
Observations	7,401,362	5,603,761	4,097,344	2,753,449	1,341,266

APPENDIX TABLE 11
Impacts of Value-Added on College Quality by Grade

College Quality at Age 20					
	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
Teacher Value-Added	226 (31)	289 (33)	292 (48)	482 (61)	198 (48)
	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
Teacher Value-Added	194	270	173	402	198

This table presents the regression estimates plotted in Figure 7; see notes to that figure for details.

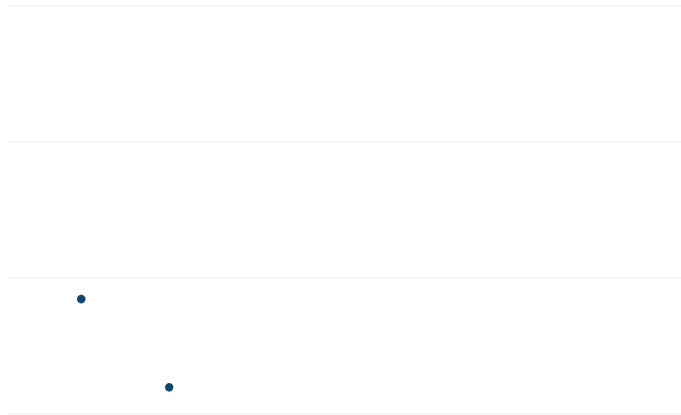
	Grade 5	Grade 6	Grade 7	Grade 8
Grade 4 Teacher VA	0.028	0.057	0.024	0.027

Years Used to Estimate VA	Present Value of Earnings Gain per Class	Undiscounted Sum of Earnings Gain per Class	Present Value of Earnings Gain per Class	Undiscounted Sum of Earnings Gain per Class
---------------------------	--	---	--	---

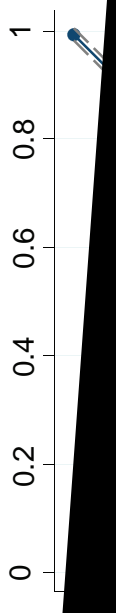
FIGURE 2

Effect of Teacher Value-Added on Earnings

a) Earnings at Age 28



Impact of Current Teacher VA on Test Scores



E

FIGURE 5

Effects of Changes in Teaching Staff Across Cohorts on College Outcomes

a) Change in College Attendance Across Cohorts vs. Change in Mean Teacher VA

FIGURE 7

APPENDIX FIGURE 1

Stability of College Rankings by Age of Earnings Measurement

a) Rankings of Colleges Based on Earnings at Ages 23 and 27 vs. Age 32

