Supplemental Material for: Jesse Rothstein. 2019. "Inequality of Educational Opportunity? Schools as Mediators of the Intergenerational Transmission of Income." Journal of Labor Economics 37(S1). DOI: 10.1086/700888.

Inequality of Educational Opportunity? Schools as Mediators of the Intergenerational Transmission of Income

Web Appendix

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A Additional results

This appendix discusses additional specifications and results not included in the main tables.

A.1 Descriptive statistics

I begin with descriptive statistics for the samples used.

Appendix Table A1 presents the national relationship between parental income and child achievement, as in Table 3, column 1, for each of the achievement measures available in the ECLS, HSLS, and ELS, as well as for several summaries of educational attainment from the ELS. Parental income is less strongly related to children's test scores in the HSLS and ELS than in the ECLS, but it is not clear whether this reflects differences across grades or differences among the surveys. There is no indication of an age gradient within any individual survey.

Appendix Figure A1 presents scatterplots of mean child outcomes for each of the 13 parental income categories reported in the ELS. Parental income is scaled as a percentile, as in the main analysis, as are children's test scores, earnings, and family incomes. One of the parental income categories, zero income, is quite rare – only 0.2% of all observations – so is indicated by hollow markers. For all four of the outcomes presented, the relationship with parental income is reasonably linear in these percentile plots, supporting the scaling choices adopted above. Appendix Table A7, discussed below, shows that my main results are robust to the use of several alternative scales.

A.2 Additional analyses of primary specifications

Next, I present analyses using the same interacted specifications as in the main analysis.

Appendix Figure A3 repeats the exercise from Figure 2 for other relationships. As in Figure 2, CZs are divided into deciles by θ_c, and regressions are estimated separately for each decile. In panel A, the within-decile regression is of children's income on parental income. This is a semi-parametric version of the model from Table 8, column 1. As there, the coefficient across θ is quite high, and points are fairly tightly clustered around the best-fit line. Panel B repeats Figure 2, using the child's test score as the dependent variable. While there is a positive slope here, it is much attenuated, and there is a great deal more variability around the best-fit line. Panels C and D present coefficients from child income regressions that control for test scores and parental income simultaneously. The test score coefficients, in Panel C, estimate λ_c, while the parental income coefficients, in Panel D, estimate μ_c. We see a steep slope in Panel C. In Panel D, the μ_c estimates are also more strongly correlated with θ_c than are the π_c coefficients in panel B. This supports the conclusion in the paper that μ_c is a more important channel for explaining θ_c than is π_c.

Appendix Table A2 presents interacted and mixed models for the relationship between parental income and children's income in the ELS. The mixed model in column 5 repeats the results from Table 8, column 1; other columns here present simpler models without random coefficients. Across all the columns, the interaction coefficients are around 0.65 or higher, and in the random effects specifications the expected coefficient of 1 is outside of the confidence interval. CZs that CHKS estimate have higher parent-to-child income transmission also have higher transmission in the ELS, but not by quite as much. In the mixed model in column 5, the across-CZ standard deviation of income transmission is smaller than in CHKS's estimates, 0.037 vs. 0.057, but they are nearly perfectly correlated. This high correlation is not surprising, of course, since θ_c is *defined* as the return to parental income in children's income, and the π_c obtained from the ELS sample differs from this only because the income measures and cohorts differ slightly. Thus, the high correlation serves to validate the use of the ELS sample for this exercise.

However, the small coefficient β, 0.64 in Column 5 and similar in earlier columns, and the correspondingly low estimated $\sigma_{\theta^{ELS}}$, remains a concern. If the ELS and tax measures were perfectly comparable, β should equal one. The attenuated coefficient must reflect differences in the income concepts between the ELS and the tax data, either for parents or for children. A likely suspect is that the ELS children's income is measured at a younger age than in the tax data, mid-20s vs. the early 30s. This may attenuate income transmission, as 25-year-olds are often not yet settled in their careers or families. Another potential explanation is that the ELS parental income measure is from only a single year and is reported in bins, so likely measures parents' permanent income with error. However, when parents were asked their incomes several times in different ECLS waves, binned measures like those reported by the ELS are correlated around 0.85 across waves, and around 0.95 with a measure constructed from the three-wave average. Thus, pure measurement error relative to permanent income does not fully account for the attenuation of β. Nevertheless, it may somewhat attenuate estimates of θ^{ELS}; in this case, the ELS is also likely to yield attenuated estimates of π_c. Any variation in the reliability of p_{ic} across CZs would tend to lead me to overstate the association between θ_c and π_c.

In Table 6, I showed that high-θ_c CZs have stronger relationships, on average, between parental income and children's college graduation and years of education. But I omitted from that table results for any college, the one mediator that CHKS are able to measure, due to the evident differences between the ELS version of this variable (with a sample mean of 0.84) and versions that can be constructed from CHKS's tax data (mean = 0.60) or the ACS sample (mean = 0.53). It appears that some students with weak attachment to higher education – perhaps they enrolled briefly and dropped out, or signed up for a program at a non-accredited institution – are reporting some postsecondary enrollment in the ELS but are not captured in other surveys. Consistent with this, 70% of those with some college in the ACS have at least an associates degree, but in the ELS this share is around half.

Appendix Table A3 explores transmission to any college in the ELS, using successively more restrictive definitions of college enrollment, in the basic random effects and mixed models. In columns 1-2, I use the ELS measure without adjustment. Column 2 indicates that the transmission of parental income to child college-going is *negatively* correlated with CZ income transmission. This is in stark contrast to CHKS's results for income-enrollment transmission using their measure of whether tuition was paid for a student between ages 18 and 21 at an institution that made an information report to the IRS, which indicated a correlation of 0.68 with θ_c.

Remaining columns tighten the definition of college enrollment. In columns 3-4, I count students who attended postsecondary education but did not get any certificate, degree, or other sort of credential as non-attendees; in columns 5-6 I include these students but exclude those who received only certificates; and in columns 7-8 I turn instead to an indicator for having an associates degree or more. Each of these specifications yields a positive (albeit weak in some cases) correlation between θ_c and π_c, suggesting that the anomalous results in columns 1-2 are driven by the students with the least meaningful connections to college. In column 8, the correlation approaches that obtained by CKHS.

A.3 Alternative transmission measures

All of the results in the main paper and in Appendix A.1 use CHKS's preferred relative mobility measure. Here, I explore three alternative measures.

Appendix Table A4 continues the exploration of transmission from parental income to children's educational attainment. Here, I repeat the mixed model specifications for each of the attainment measures from Table 6 and Appendix Table A3, but in place of CHKS's preferred measure of income transmission, I use their analogous measure of the transmission from parental income to children's college enrollment in the CZ. That is, in this table θ_c is the slope of an indicator for ever enrolling in college between 18 and 21 on the parents' income percentile. Not surprisingly given the discussion above, this is only weakly correlated with π_c in column 1, where the dependent variable is an indicator for any college by the age-26 ELS survey. This is a further indication that the ELS measure may be over-broad. Correlations and slopes of θ_c with respect to π_c are much higher in the subsequent columns. Indeed, transmission from parent income to child's educational attainment in years, or to attainment of a two-year degree, is correlated 0.8 with CHKS's θ_c measure. Appendix Table A2 also indicated that college completion and years of education are more strongly related to parental income, at a national level, than is the ELS college enrollment measure, further indicating limitations of the latter.

Appendix Table A5 returns to the income transmission concept for θ_c, but explores two alternative measures. One, labeled "later," is the measure computed by CHKS for the younger, 1983-5 birth cohorts, with adult incomes measured at younger ages. The second, "causal" measure is constructed by Chetty and Hendren (2018) based on families that move from one CZ to another. Three dependent variables are considered: Children's adult family income (in percentiles, 0-100), children's 12th grade math scores (also in percentiles), and the child's years of completed education as of age 26 (multiplied by 100). Results are generally similar across mobility measures; if anything, the alternative measures yield weaker relationships with ELS transmission from parental income to children's achievement and attainment.

A.4 Robustness to scaling and additional controls

CHKS's θ_c is strongly correlated with CZ-level racial composition, raising the possibility that what appears to be variation in the transmission of parental income is in fact due to differences in the omitted variable bias due to differences in the correlation of race with parental income. Appendix Table A6 considers the same three outcomes considered earlier along with the baseline CHKS mobility measure for the 1980-2 cohorts, but adds to this base specification indicators for the child's race and gender and, in columns 3, 6, and 9, interactions of these with the income transmission measure. I do not present results for the forward regression here, as with controls equation (**??**) is not valid. There is some evidence here that race is an important factor – the standard deviation of income transmission implied by the ELS data falls from 0.038 without controls to 0.023 when race is controlled and allowed to interact with θ_c. However, the general conclusions that income transmission is positively but weakly correlated with test score transmission, and somewhat more strongly correlated with attainment transmission, are robust to the additional controls. There is no indication that the omission of race leads me to substantially overstate the mediating role of human capital.

Appendix Table A7 explores the sensitivity of my main test score transmission results

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to different scaling choices. In column 2, I use the child's test score in standard deviations, rather than in percentiles. Column 3 rescales the test score in terms of the predicted earnings associated with that score, as in Bond and Lang (Forthcoming). Columns 4 and 5 return to using the test score percentile but rescale parental income, using first the log of parental income and then a predicted test score percentile given parental income. While the scale of the coefficients varies across these columns, the general pattern that π_c is correlated around 0.3 with θ_c is robust to each of the alternative scalings.

A.5 Loosening the normality assumption

Most of my analysis is based on a mixed model, equation (**??**). I estimate this model by maximum likelihood, under the assumption that α_c and η_c are jointly normal, that ϵ_{ic} is also normal and independent of the former two, and that all three are orthogonal to $\bar{p}_c$, $p_{ic} - \bar{p}_c$, θ_c, and the interactions $\bar{p}_c \theta_c$ and $(p_{ic} - \bar{p}_c)\,\theta_c$. The normality restrictions are unattractive, however.

In this appendix, I present an alternative, two-step estimator that does not rely on normality. Unfortunately, it is very poorly behaved in the ELS sample.

Specifically, I estimate separate regressions of children's test scores on parental income in each CZ. Samples are quite small – the median CZ has 85 observations, but 10% of CZs have fewer than 20 observations. I discard CZs with 10 or fewer observations, the 1st percentile of the sample. For all other CZs, I estimate $\hat{\pi}_c$ and its associated standard error. In computing the standard errors, I pool data from all CZs to estimate σ^2_ϵ, the residual variance; I do not take account of the multi-stage nature of the sample, which almost certainly leads me to understate the sampling error in $\hat{\pi}_c$.

Appendix Figure A2 plots the $\hat{\pi}_c$ estimates and their confidence intervals against θ_c. While there is a correlation, it is difficult to see in the graph, as the individual $\hat{\pi}_c$ estimates are extremely noisy. A regression of $\hat{\pi}_c$ on θ_c yields coefficient $\beta = 0.13$, notably smaller than seen earlier but highly significant. The residual from this regression is $\hat{\eta}_c$. It equals η_c plus a sampling error component, the distribution of which is estimated by the standard error of $\hat{\pi}_c$. To estimate σ^2_η, then, I compute the variance across CZs of $\hat{\eta}_c$ and subtract the

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component implied by the estimated standard errors:

$$\hat{\sigma}_{\eta}^{2} = \frac{1}{J-1}\sum_{c=1}^{J}\hat{\eta}_{c}^{2} - \frac{1}{J}\sum_{c=1}^{J}\hat{V}\left(\hat{\pi}_{c}\right). \tag{1}$$

In practice, this is negative – the average of (conservatively estimated) sampling variances is larger than the total variance of the coefficients (after removing the component explained by θ_c). I interpret this as an indication that the available sample is too small to support this sort of exercise – the noise in the estimated sampling variances is too large relative to the signal we are attempting to extract from the estimated coefficients. The exercise can perhaps be interpreted as evidence that normality assumptions are not leading me to understate β. However, for the full variance decomposition and estimation of the forward regression (**??**), there is no alternative for my purposes to the normality assumption imposed in the main text.

A.6 Non-cognitive skills

Finally, Appendix Table A8 presents an analysis of children's non-cognitive skills. These are drawn from batteries included in the the ELS 10th grade survey (panel A), the ECLS 5th grade student survey (panel B), and the ECLS 5th grade teacher survey (panel C). The specific measures are:

ELS 10th grade survey. Each of the measures used is created by principal factor analysis from student responses to questions of the form "How often do these things apply to you?", with response options "almost never," "sometimes," "often," and "almost always." Quotations are from National Center for Education Statistics. (undated).

- **Instrumental motivation.** Intended to capture "motivation to perform well academically in order to satisfy external goals like future job opportunities or financial security." Based on three responses about whether the student studies in order to achieve long-run success.
- **General effort and persistence.** Based on five questions characterizing effort put into studying.
- **General control beliefs.** Intended to capture "expectations of success in academic learning." Based on four responses characterizing the student's self-perceived ability to achieve desired academic outcomes.

Self efficacy, math. Based on five responses characterizing the student's self-perceived ability to succeed in math classes and his/her views about the importance of innate ability in math.

Self efficacy, reading. Based on five responses characterizing the student's self-perceived ability to succeed in reading classes.

ECLS 5th grade student survey. Students rated 42 statements about their perceptions of themselves as "not at all true," "a little bit true," "mostly true," and "very true." These were averaged into several scales. Quotations are from Tourangeau et al. (2006).

Perceived interest / competence in reading. Eight statements concerning "reading grades, the difficulty of reading work, and [the student's] interest in and enjoyment of reading."

Perceived interest / competence in math. Eight statements concerning "mathematics grades, the difficulty of mathematics work, and [the student's] interest in and enjoyment of mathematics."

Perceived interest / competence in all school subjects. Six statements concerning "how well [the student] do[es] in 'all school subjects' and [the student's] enjoyment of 'all school subjects."'

Perceived interest / competence in peer relations. Six statements concerning "how easily [the student] make[s] friends and get[s] along with children as well as their perception of their popularity."

Externalizing problem behaviors. Six statements concerning "externalizing problem behaviors such as fighting and arguing 'with other kids,' talking and disturbing others, and problems with distractibility."

Internalizing problem behaviors. Eight statements concerning "internalizing problem behaviors such as feeling 'sad a lot of the time,' feeling lonely, feeling ashamed of mistakes, feeling frustrated, and worrying about school and friendships."

ECLS 5th grade teacher survey. Teachers rated 26 statements about how often students exhibited certain social skills and behaviors as "never," "sometimes," "often," and "very often." These were averaged into several scales. Quotations are from Tourangeau et al. (2006).

Approaches to learning. "Measures behaviors that affect the ease with which children can benefit from the learning environment." Based on seven items relating to "the child's attentiveness, tax persistence, eagerness to learn, learning independence flexibility, [] organization ... [and] child follows classroom rules."

Self control. "Four items that indicate the child's ability to control behavior by respecting the property rights of others, controlling temper, accepting peer ideas for group activities, and responding appropriately to pressure from peers."

Interpersonal skills. "Five items that rate the child's skill in forming and maintaining friendships; getting along with people who are different; comforting or helping other children; expressing feelings, ideas, and opinions in positive ways; and showing sensitivity to the feelings of others."

Peer relations. This is a combination of the self-control and interpersonal scales.

Externalizing problem behaviors. This scale "includes acting out behaviors": six items "rate the frequency with which a child argues, fights, gets angry, acts impulsively, [] disturbs ongoing activities ... [and] talks during quiet study time."

Internalizing problem behaviors. Four items ask about "the apparent presence of anxiety, loneliness, low self-esteem, and sadness."

For all of the non-cognitive items, I reverse-code so that higher values are better, then convert to percentiles. I also present results for an overall non-cognitive skill index from each survey. To form this, I convert each listed scale to a z-score, average them, then convert the average to percentiles.

Results are mixed. The β coefficient on the parental income - CZ income transmission interaction is generally small and not statistically significant, and frequently has the wrong sign. For about half of the measures, there is statistically significant variation across CZs in the return to parental income (i.e., $\sigma_\eta \neq 0$). Overall, there is little indication that non-cognitive skills are important mediators of income-to-income transmission. The ECLS teacher survey results, however, tell a different story, with strong associations with income transmission. This is not due to the use of different measures in the child and teacher surveys – even when the concepts overlap (e.g., for externalizing problem behaviors), results are quite different. It is not clear how to account for this discrepancy. It may indicate that teachers in high-transmission CZs tend to be more biased in their assessments of low-income children, but this is quite speculative.

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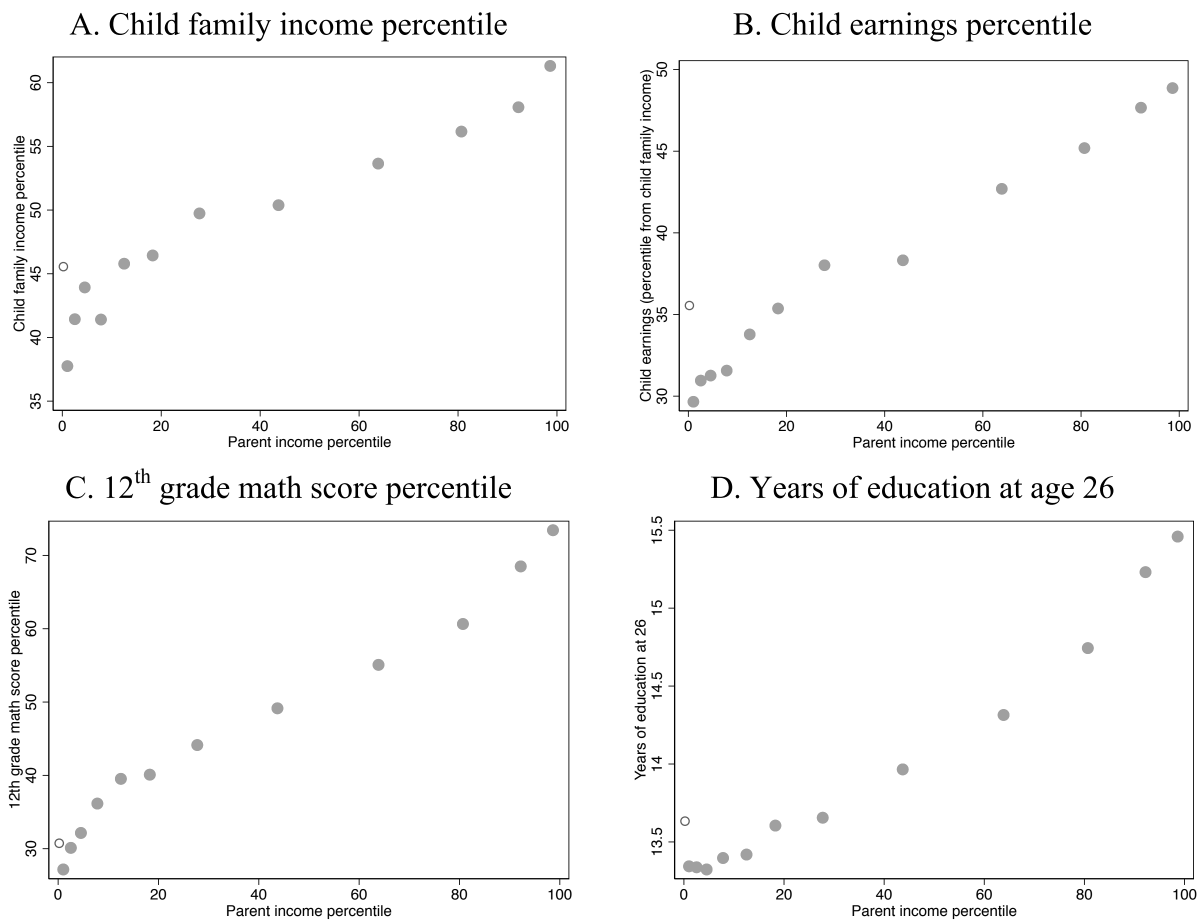
Appendix Figure A1. Mean child outcomes by parental income, ELS



Notes: Each point represents a single categorical response to the ELS parental income question, assigned to the midpoint of the percentile range covered by that category. Y-axis plots means of the indicated child outcome for each category. The hollow points represent the 0.2% of observations reporting zero parental income. Child family incomes, earnings, and 12th grade math scores are measured as percentiles of the national distributions.

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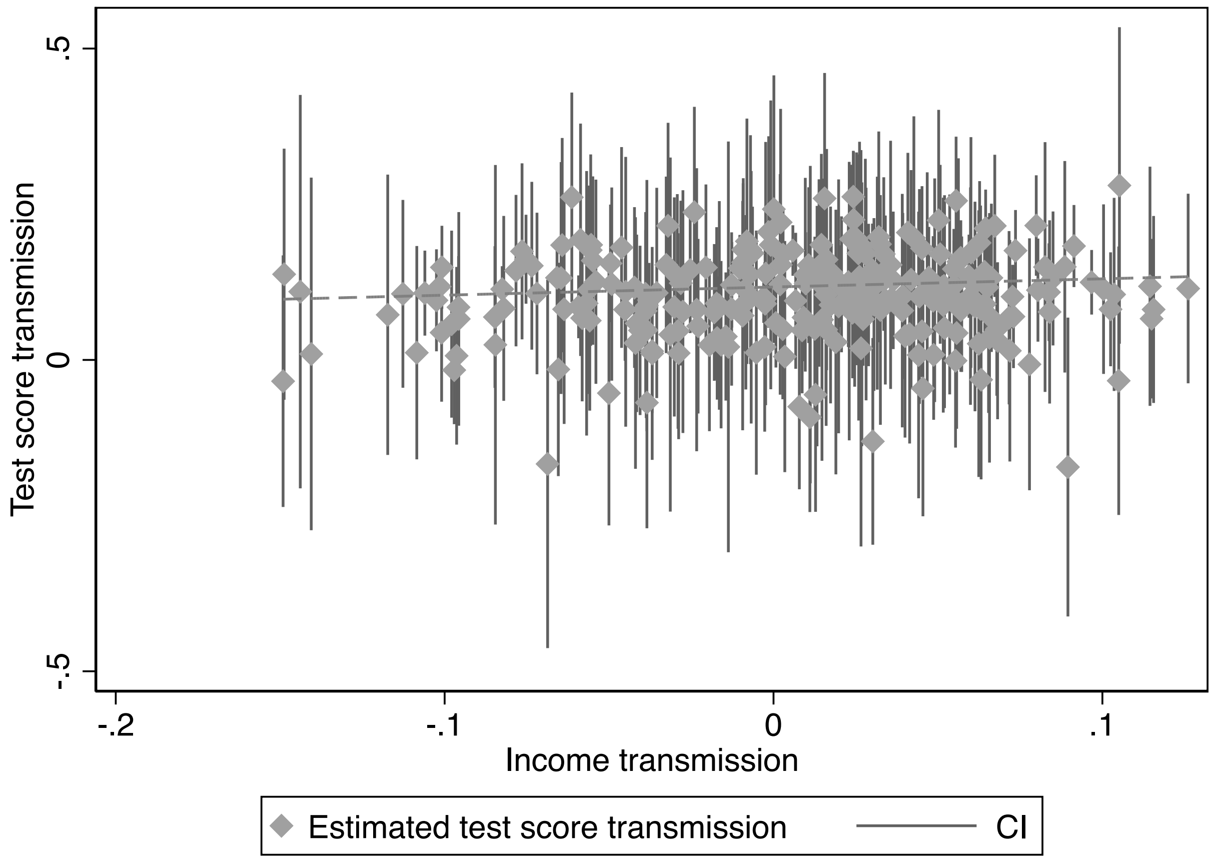
Appendix Figure A2. CZ-level estimates of parental income – child test score transmission



Notes: Points represent individual CZs. The x-axis plots the CZ's income transmission, as measured by CHKS. The y-axis represents the coefficient of a regression of the child's test score percentile on the parents' income percentile, estimated using data from a single CZ. Vertical spikes show 95% confidence intervals. Dashed line represents a regression of the CZ test score transmission coefficient on CZ income transmission, weighted by the inverse sampling variance of the former.

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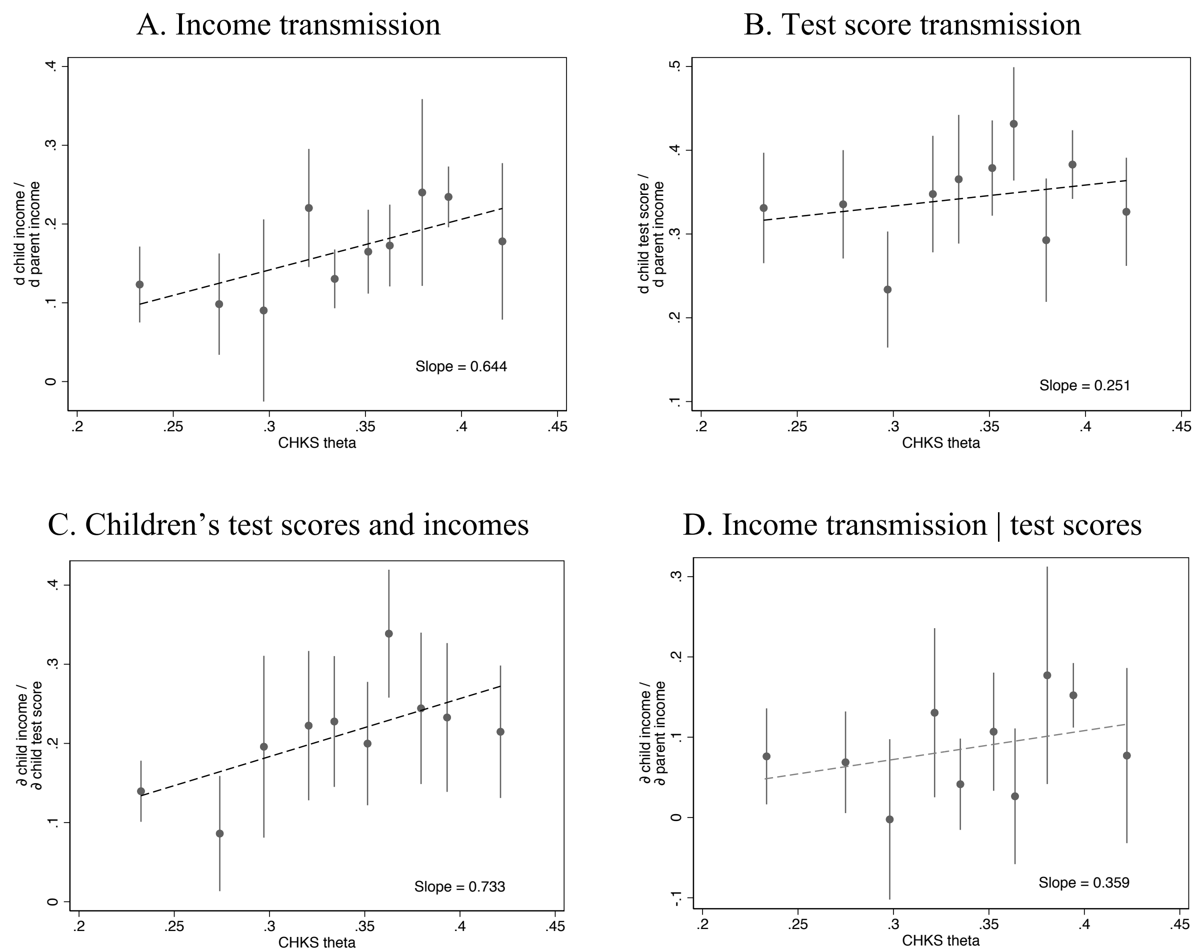
Appendix Figure A3. Parental income to child outcome transmission, by CZ income transmission (θ) decile



Notes: CZs are divided into deciles based on CHKS's income transmission (relative mobility) measure. Figure plots coefficients and 95% confidence intervals for regressions estimated separately for each decile. In Panel A, the regression is of the child's income percentile (y) on the parent's income percentile (p). In Panel B, it is of the child's test score percentile (s) on p, as in Figure 2. In Panels C and D, y is regressed on s and p; Panel C shows the s coefficients and Panel D shows the p coefficients. Each regression includes CZ fixed effects and uses ELS sampling weights. Dashed lines show unweighted regressions of the decile coefficients on the decile mean income transmission; their slopes are shown in the lower right of each panel.

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Appendix Table A1. Transmission from parental income to children's outcomes at the national level, by sample, grade, and subject

	Math		Reading		Other	
	Coefficient	N	Coefficient	N	Coefficient	N
	(1)	(2)	(3)	(4)	(5)	(6)
ECLS-K						
K (spring)	0.40	19,190	0.36	18,500		
	(0.01)		(0.01)			
G1 (spring)	0.41	16,370	0.37	16,080		
	(0.01)		(0.01)			
G3	0.42	14,180	0.43	14,090		
	(0.01)		(0.01)			
G5	0.43	11,140	0.43	11,130		
	(0.02)		(0.02)			
G8	0.42	9,210	0.44	9,150		
	(0.02)		(0.02)			
HSLS						
G9	0.32	20,170				
	(0.01)					
G11	0.31	20,460				
	(0.01)					
ELS						
G10	0.34	15,240	0.32	15,240		
	(0.01)		(0.01)			
G12	0.35	13,650				
	(0.01)					
Any college (*100)					0.24	13,250
					(0.01)	
College completion (*100)					0.45	13,250
					(0.02)	
Years of education (*100)					1.87	13,250
					(0.07)	
Income at 26					0.16	11,510
					(0.01)	

Notes: Each entry represents the coefficient from a separate weighted least squares regression of the child's outcome on family income, with commuting zone fixed effects. Parental incomes, test scores, and child incomes are measured in percentile units, scaled 0-100. Any college and college completion are binary, but scaled as 0/100 for readability; years of education is multiplied by 100 for the same reason. Sample sizes are rounded to the nearest 10.

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Appendix Table A2. Income transmission in the ELS

	(1)	(2)	(3)	(4)	(5)
Parental income - CZ mean	0.16	0.16	0.17	0.16	0.17
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
CZ mean parental income	0.32	0.33	0.34		0.34
	(0.04)	(0.04)	(0.04)		(0.04)
CZ income transmission (θ)		-62.7	-65.2		-76.5
		(32.9)	(29.8)		(30.9)
(Parental income - CZ mean)		0.71	0.63	0.64	0.64
* CZ income transmission (θ)		(0.20)	(0.16)	(0.20)	(0.16)
CZ mean parental income		1.08	1.27		1.34
* CZ income transmission (θ)		(0.66)	(0.57)		(0.61)
SD of parental income random coefficient (η)					0.006
					(0.018)
CZ effects	None	None	RE	FE	RE
Across-CZ distribution:					
SD of CHKS CZ income transmission (θ^{CHKS})		0.057	0.057	0.057	0.057
SD of ELS income transmission (θ^{ELS})		0.040	0.036	0.036	0.037
Coefficient of between-CZ regression of θ^{CHKS} on θ^{ELS}					1.52
					(0.37)
R^2					0.97
Corr(θ^{CHKS}, θ^{ELS})		1	1	1	0.99
p-value, SD(η) = 0 / corr(θ^{CHKS}, θ^{ELS}) = 1 (LR test)					0.92

Notes: Dependent variable in each column is the child's family income at age 26, in percentile units (0-100). Specifications are otherwise identical to those in Table 4; see notes to that table for details. Number of observations (rounded to the nearest 10) = 11,510.

Appendix Table A3. Parental income and children's educational attainment in the ELS

	Any college (0/100)		Exclude those with no credentials at all		Exclude certificates		2 year degree or more	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Parental income - CZ mean	0.22	0.24	0.37	0.38	0.28	0.30	0.44	0.44
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
CZ mean parental income	0.49	0.48	0.78	0.79	0.69	0.70	0.98	0.99
	(0.05)	(0.04)	(0.07)	(0.07)	(0.06)	(0.05)	(0.07)	(0.06)
CZ income transmission (θ)	-52	-51	-64	-67	-59	-59	-70	-68
	(47)	(41)	(69)	(66)	(46)	(42)	(61)	(60)
(Parental income - CZ mean)	-0.11	-0.20	0.37	0.32	0.12	0.08	0.60	0.56
* CZ income transmission (θ)	(0.20)	(0.21)	(0.29)	(0.27)	(0.22)	(0.23)	(0.31)	(0.27)
CZ mean parental income	0.97	0.93	1.42	1.42	1.02	1.01	1.42	1.41
* CZ income transmission (θ)	(0.91)	(0.78)	(1.37)	(1.29)	(0.90)	(0.80)	(1.20)	(1.18)
SD of parental income random coefficient (η)		0.10		0.07		0.09		0.05
		(0.02)		(0.02)		(0.01)		(0.02)
Across-CZ distribution:								
SD of CZ income transmission (θ)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
SD of p-attainment transmission (π)	< 0	0.10	0.02	0.07	0.01	0.09	0.03	0.06
Coefficient of regression of θ on π		-0.06		0.22		0.04		0.51
		(0.06)		(0.18)		(0.10)		(0.29)
R^2		0.01		0.07		0.00		0.29
Corr(θ, π)	1	-0.11	1	0.27	1	0.05	1	0.54
p-value, SD(η) = 0 / corr(θ, π) = 1 (LR test)		<0.01		<0.01		<0.01		0.04

Notes: Specifications are as in Table 4, columns 3 (odd numbered columns here) and 5 (even numbered columns). See notes to that table for details. Dependent variables are scaled as 0 for failures and 100 for successes. Columns 3-8 recode some successes from columns 1-2 as failures, but are otherwise identical. Number of observations (rounded to the nearest 10) = 13,250.

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Appendix Table A4. Models using CHKS's measure of CZ-level transmission of parental income to children's college enrollment

	Any college (0/100)	College graduate (0/100)	Years of education (*100)	Any college credential (0/100)	Any college exc. UG certificates (0/100)	2 year degree or more (0/100)
	(1)	(2)	(3)	(4)	(5)	(6)
Parental income - CZ mean	0.23	0.45	1.85	0.38	0.29	0.44
	(0.01)	(0.02)	(0.06)	(0.02)	(0.01)	(0.01)
CZ mean parental income	0.46	0.97	3.97	0.76	0.69	0.97
	(0.04)	(0.06)	(0.25)	(0.06)	(0.05)	(0.06)
CZ transmission of parental income to	-71	-105	-461	-132	-52	-111
children's college enrollment (θ)	(28)	(39)	(146)	(32)	(34)	(35)
(Parental income - CZ mean)	0.29	0.66	2.84	0.57	0.36	0.63
* CZ income-enrollment transmission (θ)	(0.13)	(0.18)	(0.70)	(0.18)	(0.14)	(0.17)
CZ mean parental income	1.10	2.09	9.13	2.35	0.81	2.05
* CZ income-enrollment transmission (θ)	(0.53)	(0.79)	(2.93)	(0.64)	(0.65)	(0.70)
SD of parental income random coefficient (η)	0.10	0.07	0.19	0.05	0.08	0.04
	(0.01)	(0.03)	(0.12)	(0.02)	(0.01)	(0.02)
Across-CZ distribution:						
SD of CHKS enrollment transmission (θ)	0.09	0.09	0.09	0.09	0.09	0.09
SD of p-attainment transmission (π)	0.10	0.09	0.31	0.07	0.08	0.07
Coefficient of regression of θ on π	0.22	0.59	0.22	0.80	0.38	1.02
	(0.10)	(0.26)	(0.10)	(0.25)	(0.15)	(0.34)
R^2	0.06	0.39	0.63	0.45	0.14	0.64
Corr(θ, π)	0.25	0.62	0.80	0.67	0.37	0.80
p-value, SD(η) = 0 / corr(θ, π) = 1 (LR test)	<0.01	0.21	0.60	0.03	<0.01	0.10

Notes: Specifications are as in Table 4, column 5, but use a different CZ-level transmission measure for θ. See notes to Table 4 for details. Dependent variables in columns 1-2 and 4-6 are scaled as 0 for failures and 100 for successes; in column 3, dependent variable is years of education multiplied by 100. Number of observations (rounded to the nearest 10) = 13,250.

Supplemental Material for: Jesse Rothstein. 2019. "Inequality of Educational Opportunity? Schools as Mediators of the Intergenerational Transmission of Income." Journal of Labor Economics 37(S1). DOI: 10.1086/700888.

Appendix Table A5. Alternative income transmission measures

Outcome	Child family income (percentile)			12th grade math score (percentile)			Educational attainment (years*100)		
Transmission measure	Base	Later	Causal	Base	Later	Causal	Base	Later	Causal
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Parental income - CZ mean	0.17	0.17	0.17	0.33	0.33	0.33	1.86	1.86	1.87
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.06)	(0.06)	(0.06)
CZ mean parental income	0.34	0.33	0.33	0.70	0.69	0.69	4.03	3.99	4.07
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.26)	(0.26)	(0.25)
CZ income transmission (θ)	-76	-57	-77	-73	-66	-80	-410	-429	-351
	(31)	(28)	(29)	(28)	(24)	(25)	(237)	(220)	(251)
(Parental income - CZ mean)	0.64	0.61	0.59	0.41	0.27	0.19	2.35	2.45	1.54
* CZ income transmission (θ)	(0.16)	(0.16)	(0.18)	(0.17)	(0.16)	(0.18)	(1.09)	(1.07)	(1.14)
CZ mean parental income	1.34	1.10	1.41	1.20	1.15	1.35	9.67	9.64	8.51
* CZ income transmission (θ)	(0.61)	(0.56)	(0.55)	(0.56)	(0.49)	(0.52)	(4.73)	(4.44)	(4.96)
SD of parental income random	0.01	0.01	0.00	0.07	0.07	0.07	0.22	0.23	0.25
coefficient (η)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.13)	(0.13)	(0.13)
Across-CZ distribution:									
SD of CZ income transmission (θ)	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.06	0.05
SD of p-outcome transmission (π)	0.04	0.04	0.03	0.07	0.07	0.07	0.25	0.27	0.27
Coefficient of regression of θ on π	1.52	1.52	1.67	0.26	0.18	0.10	0.12	0.12	0.06
	(0.37)	(0.44)	(0.49)	(0.12)	(0.11)	(0.09)	(0.11)	(0.10)	(0.06)
R^2	0.97	0.93	1.00	0.11	0.05	0.02	0.27	0.29	0.09
Corr(θ, π)	0.99	0.96	1.00	0.32	0.22	0.14	0.52	0.54	0.30
p-value, SD(η) = 0 (LR test)	0.92	0.82	0.99	0.00	0.00	0.00	0.33	0.36	0.26

Notes: Columns 1, 4, and 7 correspond, respectively, to Table 8, column 1; Table 4, column 5; and Table 6, column 4. Columns 2, 5, and 8 use an alternative income transmission measure computed from the 1983-5 birth cohorts. Columns 3,6, and 9 use Chetty and Hendren's (forthcoming) "causal" measure based on children who move across CZs.

Supplemental Material for: Jesse Rothstein. 2019. "Inequality of Educational Opportunity? Schools as Mediators of the Intergenerational Transmission of Income." Journal of Labor Economics 37(S1). DOI: 10.1086/700888.

Appendix Table A6. Intergenerational transmission in the ELS, with race and gender controls

	Child income			12th grade math score			Years of education at 26 (*100)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Parental income - CZ mean	0.17	0.15	0.15	0.33	0.28	0.28	1.86	1.73	1.74
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.06)	(0.06)	(0.06)
CZ mean parental income	0.34	0.28	0.27	0.70	0.57	0.56	4.03	3.66	3.67
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.26)	(0.28)	(0.28)
CZ income transmission (θ)	-76	-55	-42	-73	-56	-77	-410	-436	-476
	(31)	(31)	(35)	(28)	(25)	(34)	(237)	(261)	(277)
(Parental income - CZ mean)	0.64	0.45	0.40	0.41	0.13	0.22	2.35	1.95	2.20
* CZ income transmission (θ)	(0.16)	(0.15)	(0.16)	(0.17)	(0.16)	(0.18)	(1.09)	(0.96)	(1.00)
CZ mean parental income	1.34	1.07	0.89	1.20	0.95	1.22	9.67	9.86	10.79
* CZ income transmission (θ)	(0.61)	(0.60)	(0.63)	(0.56)	(0.51)	(0.62)	(4.73)	(5.23)	(5.44)
SD of parental income random coefficient (η)	0.01	0.00	0.00	0.07	0.06	0.06	0.22	0.17	0.17
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.13)	(0.15)	(0.17)
Race and gender		X	X		X	X		X	X
Race and gender X income transmission			X			X			X
p-value, SD(η) = 0 (LR test)	0.92	0.96	0.96	<0.01	0.02	0.02	0.33	0.18	0.19

Notes: Columns 1, 4, and 7 correspond, respectively, to Table 8, column 1; Table 4, column 5; and Table 6, column 4. Columns 2, 5, and 8 add indicators for black, Hispanic, and female; columns 3, 6, and 9 also add interactions of these variables with CZ-level income transmission. Standard errors are clustered at the CZ level. Number of observations (rounded to the nearest 10) = 11,510 for child income, 13,650 for 12th grade test scores, and 13,250 for years of education.

Supplemental Material for: Jesse Rothstein. 2019. "Inequality of Educational Opportunity? Schools as Mediators of the Intergenerational Transmission of Income." Journal of Labor Economics 37(S1). DOI: 10.1086/700888.

Appendix Table A7. Sensitivity of test score transmission to alternative scalings

Scaling of parental income	%ile	%ile	%ile	Log (income)	Predicted test score %ile
Scaling of child's test score	%ile	Z-score (*10)	Predicted earnings %ile	%ile	%ile
	(1)	(2)	(3)	(4)	(5)
Parental income - CZ mean	0.33	0.11	0.08	2.28	0.85
	(0.01)	(0.00)	(0.00)	(0.08)	(0.03)
CZ mean parental income	0.70	0.24	0.16	5.26	1.79
	(0.04)	(0.01)	(0.01)	(0.27)	(0.09)
CZ income transmission (θ)	-72.6	-24.0	-18.0	-66.4	-152.8
	(27.8)	(9.6)	(7.2)	(43.3)	(65.8)
* (Parental income - CZ mean)	0.41	0.15	0.10	2.30	0.99
	(0.17)	(0.06)	(0.04)	(1.25)	(0.42)
* CZ mean parental income	1.20	0.39	0.30	6.03	2.81
	(0.56)	(0.19)	(0.14)	(4.06)	(1.34)
SD of parental income random coefficient (η)	0.07	0.03	0.02	0.56	0.15
	(0.02)	(0.01)	(0.00)	(0.11)	(0.04)
Across-CZ distribution:					
SD of CZ income transmission (θ)	0.06	0.06	0.06	0.06	0.06
SD of parental income-test score transmission (π)	0.07	0.03	0.02	0.57	0.16
Coefficient of between-CZ regression of θ on π	0.26	0.65	1.07	0.02	0.12
	(0.12)	(0.29)	(0.50)	(0.01)	(0.06)
R^2	0.11	0.10	0.11	0.05	0.12
Corr(θ, π)	0.32	0.31	0.33	0.23	0.34
p-value, SD(η) = 0 / corr(θ, π) = 1 (LR test)	<0.01	<0.01	<0.01	<0.01	0.02

Notes: Column 1 is from Table 4, column 5. See notes to Table 4 for details. Subsequent columns vary the scaling of the dependent variable (the 12th grade math score) or the parental income measure. Number of observations (rounded to the nearest 10) ranges from 13,590 to 13,650.

Appendix Table A8. Transmission of parental income to children's non-cognitive skills

	Parental income	Parental income * CZ income transmission	SD of parental income random coefficient (η)	Corr(θ, π)	Coefficient of regression of θ on π	p-value, LR test of SD(η) = 0
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ELS (10th grade)						
Instrumental motivation	0.09	0.07	0.03	0.16	0.36	0.26
	(0.01)	(0.16)	(0.01)		(0.74)	
General effort and persistence	0.09	-0.05	0.06	-0.05	-0.05	0.02
	(0.01)	(0.21)	(0.02)		(0.23)	
General control beliefs	0.14	-0.23	0.05	-0.24	-0.25	<0.01
	(0.01)	(0.19)	(0.02)		(0.28)	
Self-efficacy - Math	0.11	0.16	0.03	0.31	0.61	0.21
	(0.01)	(0.14)	(0.01)		(0.66)	
Self-efficacy - Reading	0.14	-0.45	0.07	-0.37	-0.30	0.02
	(0.01)	(0.23)	(0.02)		(0.25)	
Index of five measures	0.14	-0.16	0.05	-0.19	-0.21	<0.01
	(0.01)	(0.18)	(0.02)		(0.28)	
Panel B: ECLS-K 5th grade student survey						
Perceived interest / competence	0.05	-0.18	0.05	-0.21	-0.23	<0.01
in reading	(0.01)	(0.21)	(0.01)		(0.28)	
Perceived interest / competence	0.02	0.07	0.04	0.11	0.17	0.44
in math	(0.01)	(0.16)	(0.02)		(0.45)	
Perceived interest / competence	0.08	0.11	0.05	0.13	0.14	0.04
in all school subjects	(0.01)	(0.21)	(0.01)		(0.27)	
Perceived interest / competence	0.07	-0.34	0.04	-0.45	-0.59	0.10
in peer relations	(0.01)	(0.17)	(0.02)		(0.50)	
Externalizing problem behaviors	0.19	0.03	0.01	0.19	1.41	0.85
	(0.01)	(0.12)	(0.01)		(8.11)	
Internalizing problem behaviors	0.18	-0.39	0.05	-0.41	-0.42	<0.01
	(0.01)	(0.17)	(0.01)		(0.23)	
Index of six measures	0.20	-0.26	0.03	-0.43	-0.72	0.17
	(0.01)	(0.17)	(0.02)		(0.86)	

Table continued on next page

Appendix Table A8 (cont'd.)

	Parental income	Parental income * CZ income transmission	SD of parental income random coefficient (η)	Corr(θ, π)	Coefficient of regression of θ on π	p-value, LR test of SD(η) = 0
	(1)	(2)	(3)	(4)	(5)	(6)
Panel C: ECLS-K 5th grade teacher survey						
Approaches to learning	0.19	0.58	0.06	0.51	0.44	0.02
	(0.01)	(0.18)	(0.02)		(0.20)	
Self-control	0.15	0.72	0.06	0.57	0.45	0.01
	(0.01)	(0.18)	(0.02)		(0.20)	
Interpersonal skills	0.15	0.22	0.05	0.25	0.28	0.16
	(0.01)	(0.17)	(0.02)		(0.21)	
Peer relations (self-control & interpersonal)	0.15	0.52	0.06	0.50	0.47	0.03
	(0.01)	(0.18)	(0.01)		(0.20)	
Externalizing problem behaviors	0.11	0.48	0.03	0.70	1.03	0.05
	(0.01)	(0.12)	(0.02)		(0.60)	
Internalizing problem behaviors	0.11	-0.02	0.07	-0.01	-0.01	<0.01
	(0.01)	(0.20)	(0.01)		(0.16)	
Index of six measures	0.21	0.59	0.07	0.47	0.37	0.02
	(0.01)	(0.21)	(0.02)		(0.15)	

Notes: Each row presents a single mixed model regression, estimated without sampling weights. Dependent variables are discrete responses, scaled so that higher numbers are better and then converted to percentiles between 0 and 100 (with discrete responses assigned to the midpoint of the relevant range). Indexes are constructed by reversing the original response scale as necessary, converting to z-scores, averaging across responses and then converting to percentiles. Parental incomes in columns 1-3 are deviated from the CZ mean. Standard errors are clustered at the CZ level.