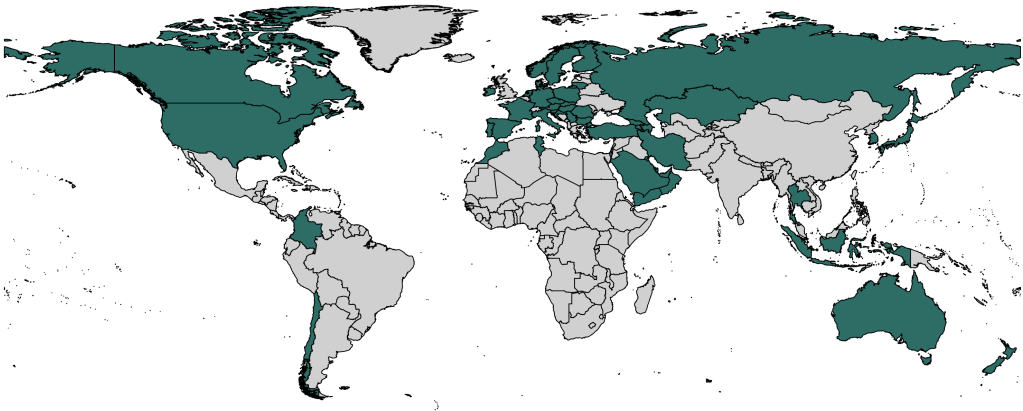
A Rosetta Stone for Human Capital

Dev Patel Justin Sandefur

Who can read better, a 4^{th}-Grader in Niger or Peru?

Coverage of International Assessments



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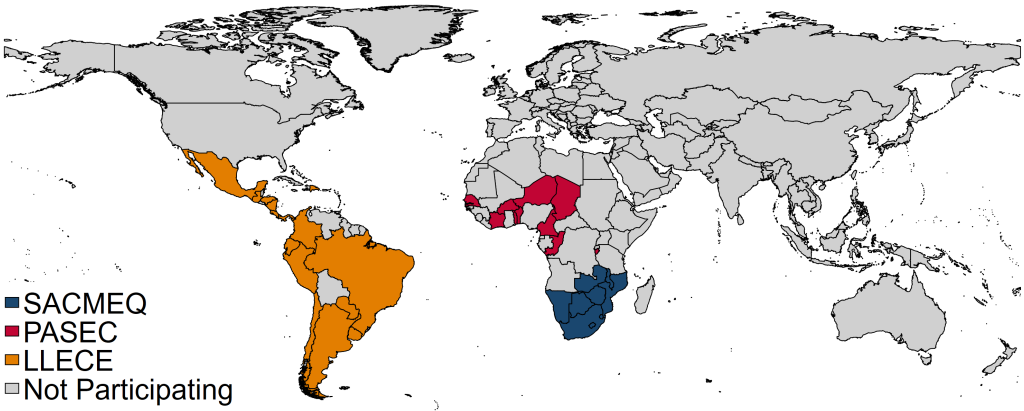

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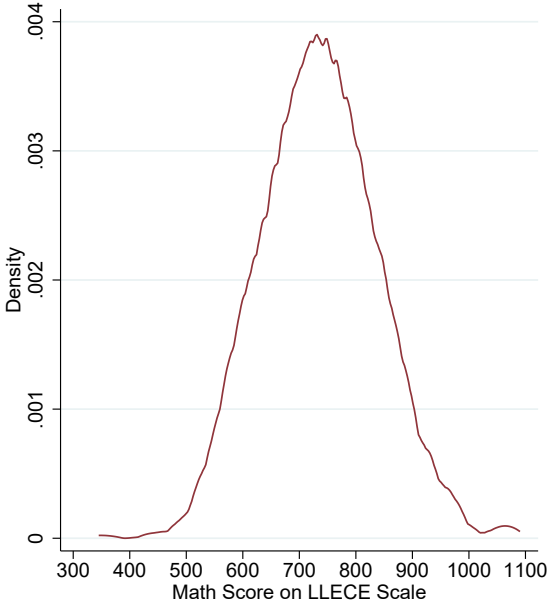
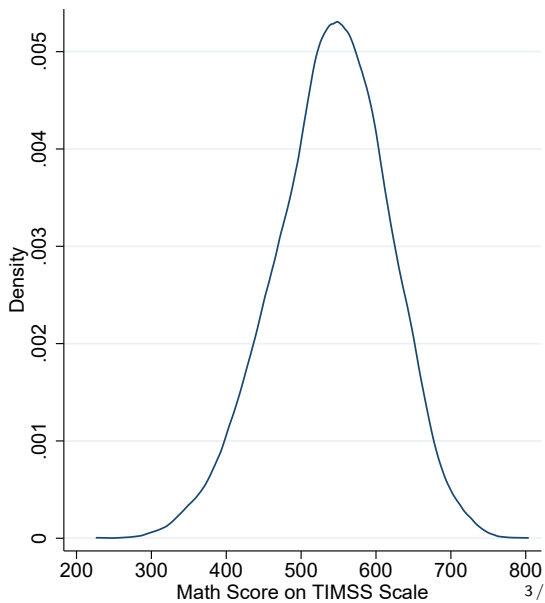
Brazil (LLECE Scale)



United States (TIMSS Scale)



Part #1: Method to “Translate” Human Capital Across Scales

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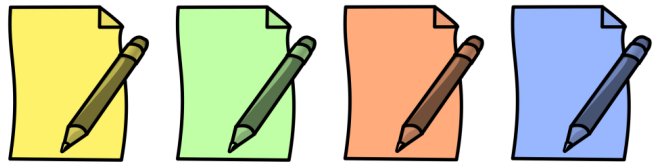
Methodological Overview



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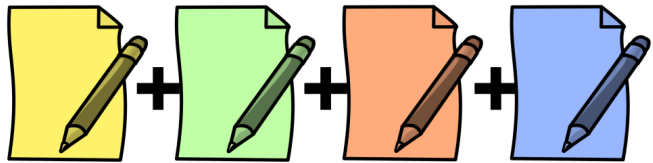

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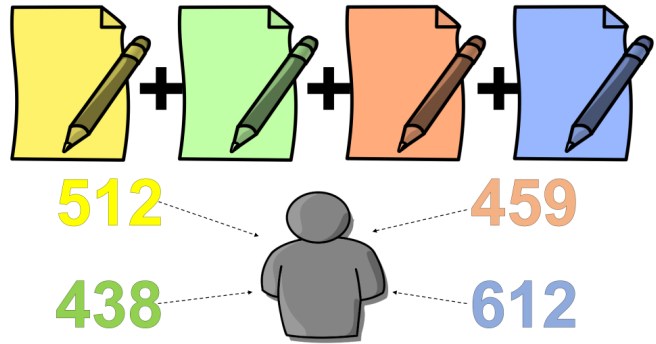

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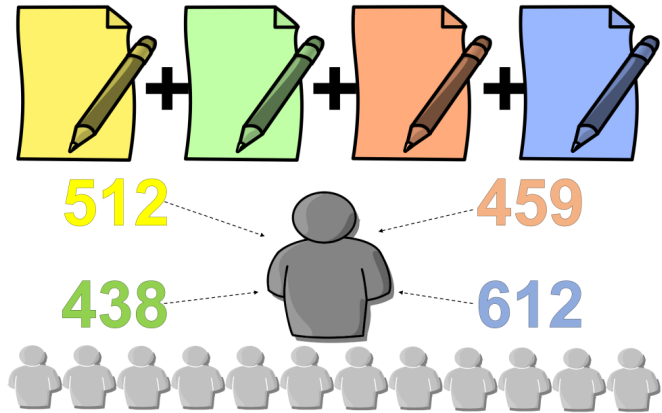

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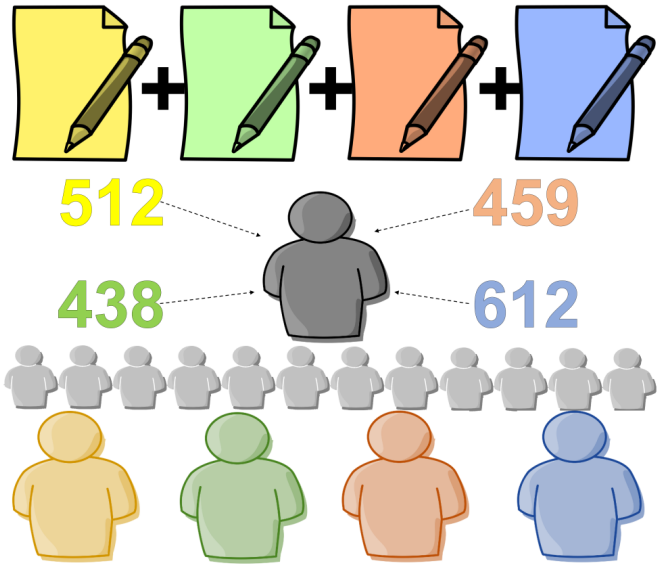

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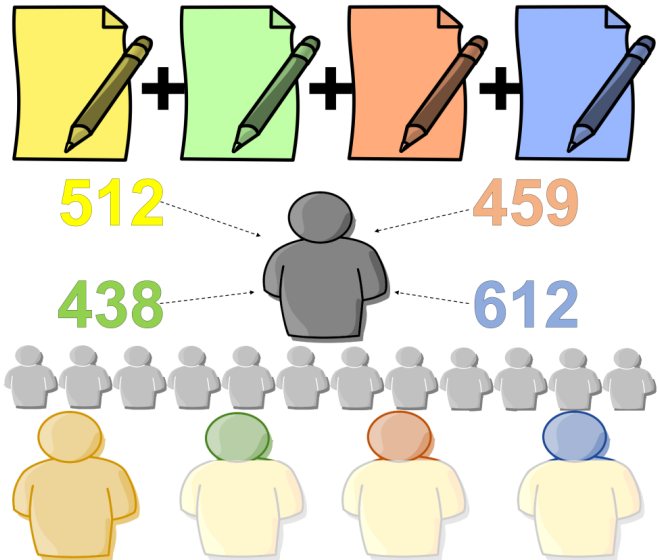

Part #2: Applications to the Global Learning Distribution

Link four largest primary-age standardized tests using data from India and U.S.
Translate math and reading scores of 600,000 pupils across 80 countries

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3. Girls read better than boys on average at all household incomes; outperform in math only below $3,000 (PPP) per capita
4. **Score gap between public and private schools increases with income inequality**

Today's Talk

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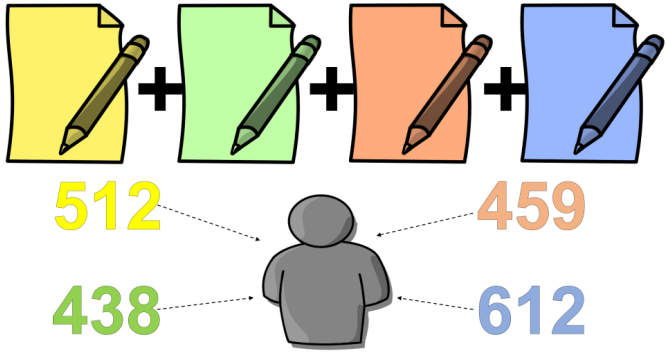
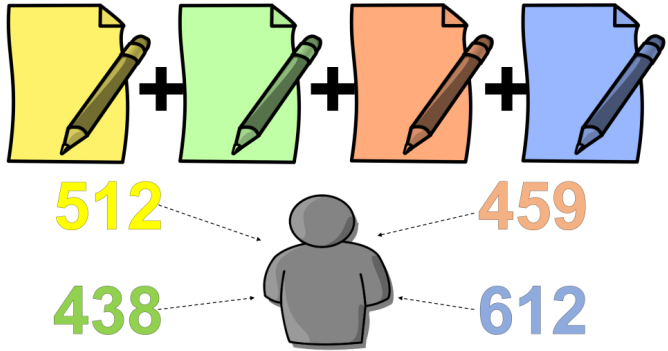
   - Overview of methodology
   - Implementation using fieldwork from India and U.S.
2. **Application to Global Learning Distribution**


512
459
438
612



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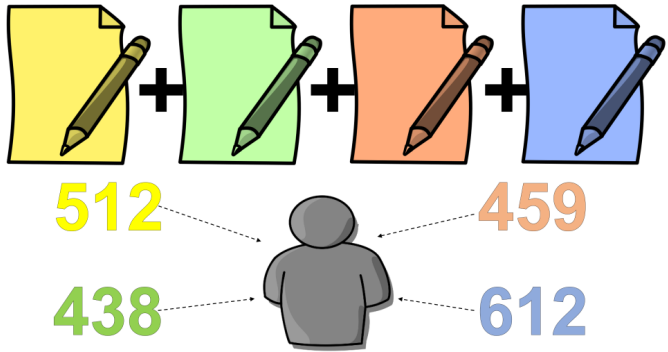

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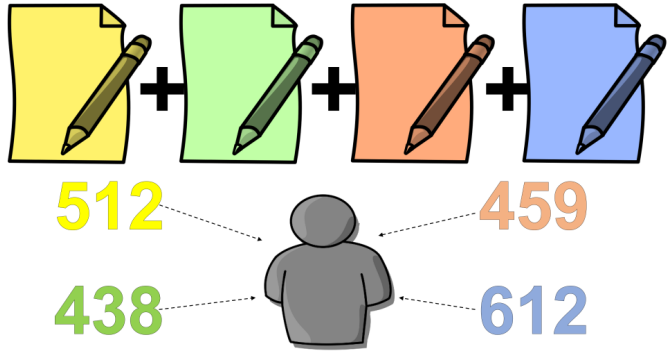

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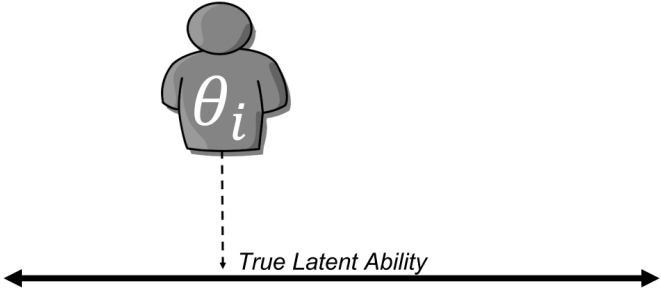
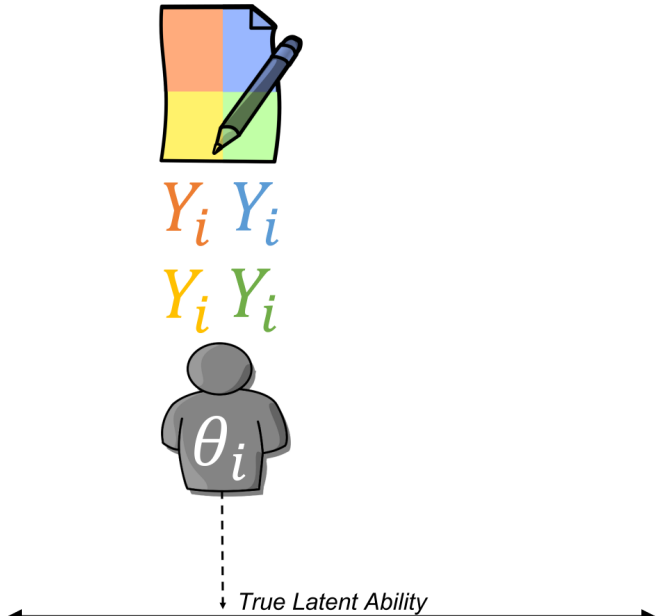
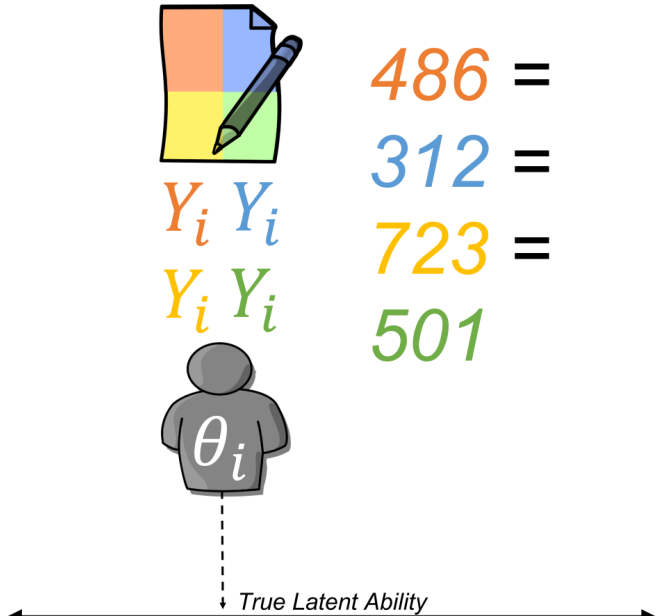
$\Rightarrow$ Build a hybrid exam consisting of some questions from each source test



- Administer hybrid exam pooling questions from target tests



- Administer hybrid exam pooling questions from target tests
- For student i, grade performance on each source scale using anchored IRT parameters



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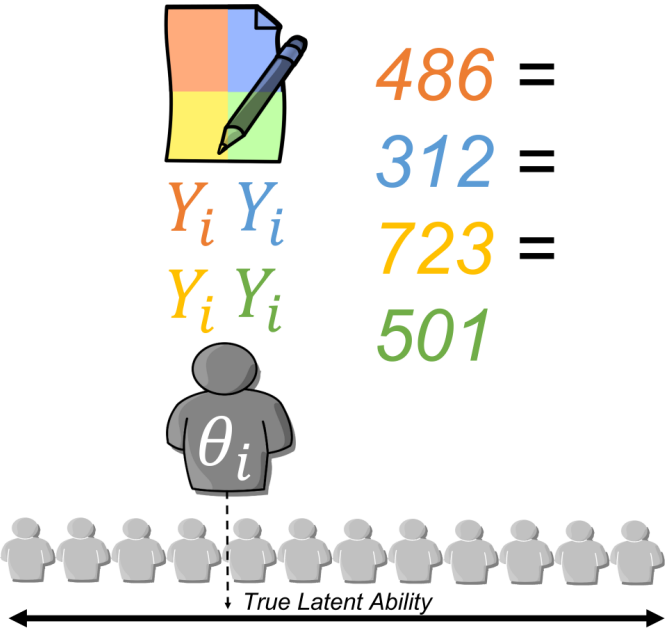


- Administer hybrid exam pooling questions from target tests
- For student i, grade performance on each source scale using anchored IRT parameters
- Because it is the same student on the same day, scores *within* pupil are comparable
- Repeat for lots of students to estimate "translations" across skill distribution

Application: Assessing the Global Learning Distribution

- Apply methodology to link four of the world's largest standardized tests spanning 80 countries:
  - TIMSS and PIRLS (OECD)
  - LLECE (Latin America)
  - PASEC (West Africa)

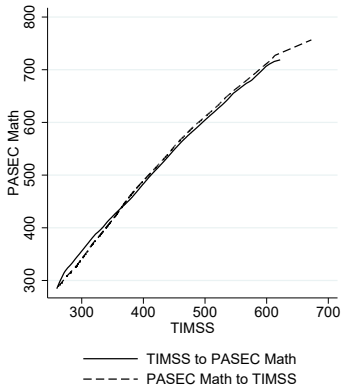
- Administer hybrid exam to two samples of elementary school students:
  - Bihar, India: 2,300 students in 4^{th}-8^{th} grade Details
  - Florida, United States: 2,200 students in 6^{th}-8^{th} grade Details

  Provides coverage across skill distribution

- Exams cover both math and reading
  - *Focus on math today for sake of time*

Test Score Conversion Functions

OECD ⇔ West Africa



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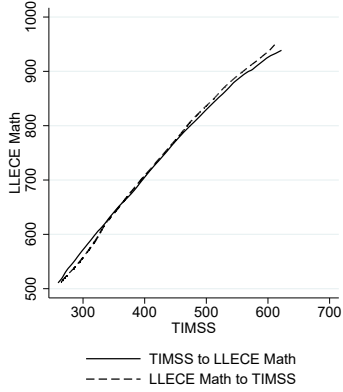
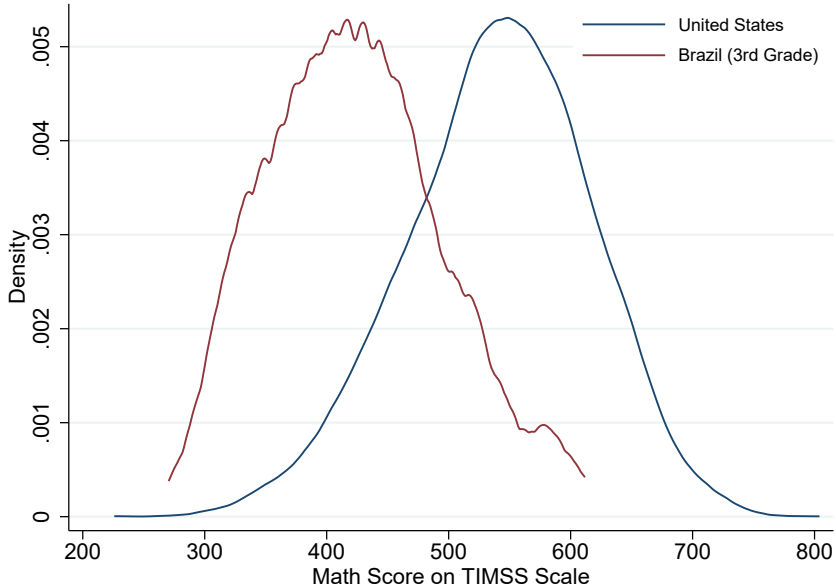


T-test results

Placing Brazil and U.S. on the Same Scale

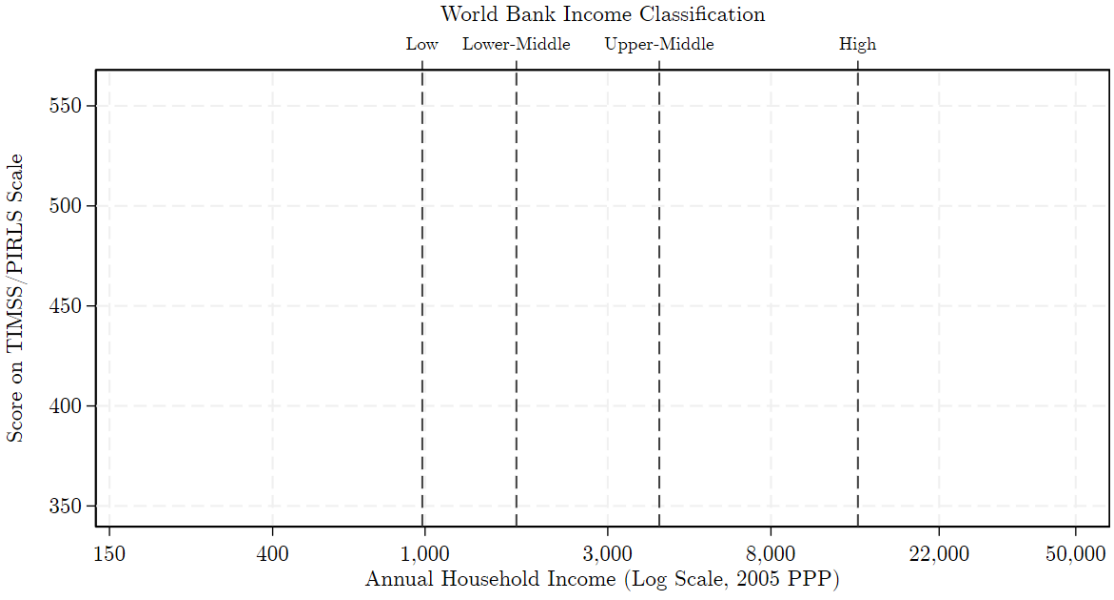


Today's Talk

1. "Rosetta Stone" Methodology
2. **Application to Global Learning Distribution**
   - Apply these translations to microdata from 628,601 students from 80 countries who participated in the source tests
   - Results that follow use TIMSS/PIRLS scales ($100 = 1\sigma$)
   - Four facts about the learning around the world

Four Facts About the Global Learning Distribution

1. **Where children live matters more than their income**
   - Students with the same household resources living in different countries can have very different educational outcomes


World Bank Income Classification
Low
Lower-Middle
Upper-Middle
High
550
500
450
400
350
Score on TIMSS / PIRLS Scale
150
400
1,000
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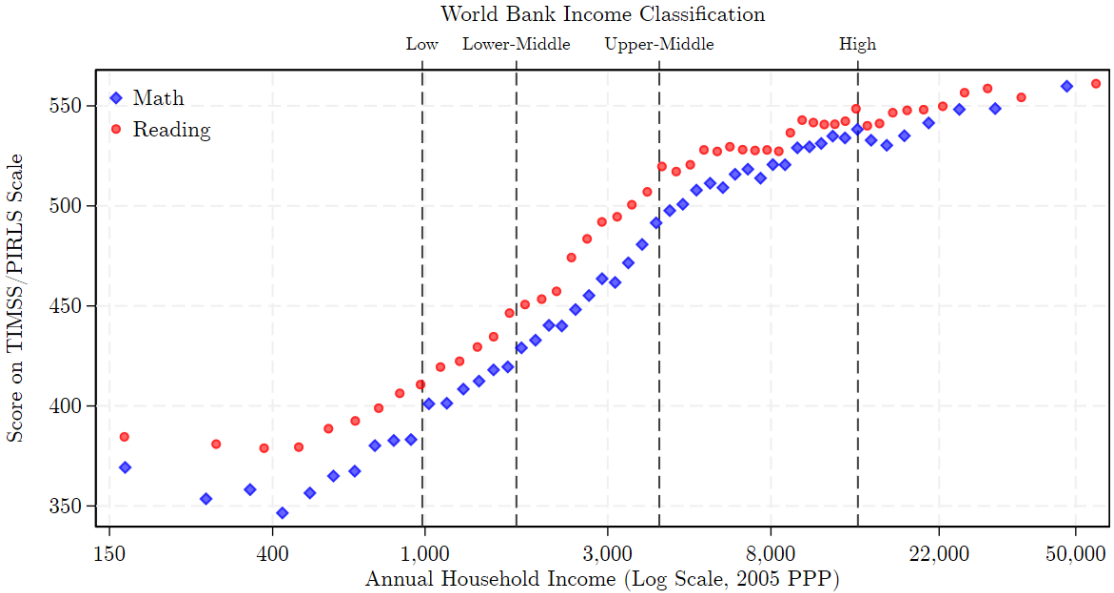
Annual Household Income (Log Scale, 2005 PPP)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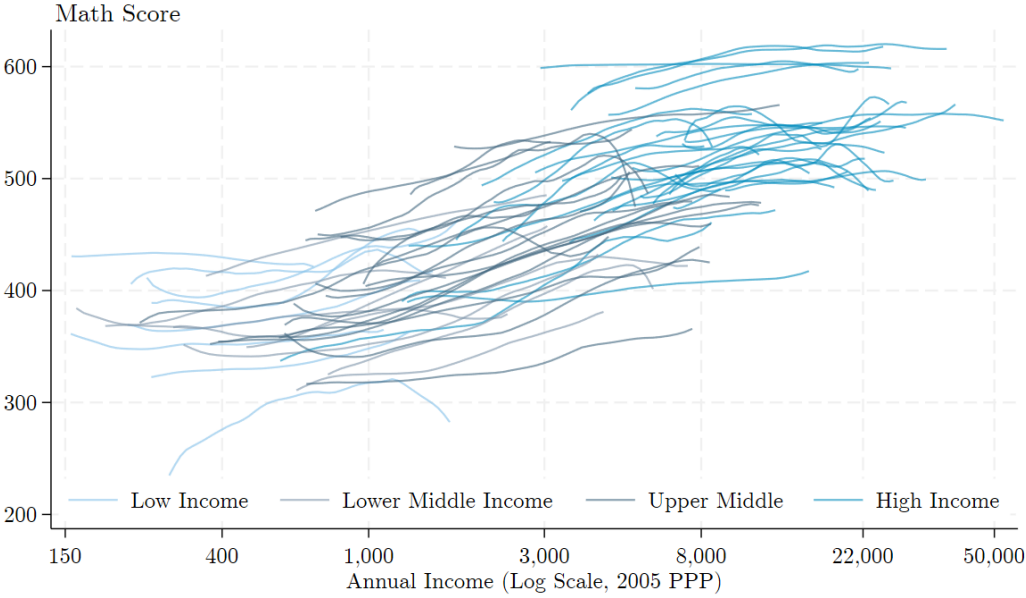
Math Score
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300
200
Low Income
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High Income
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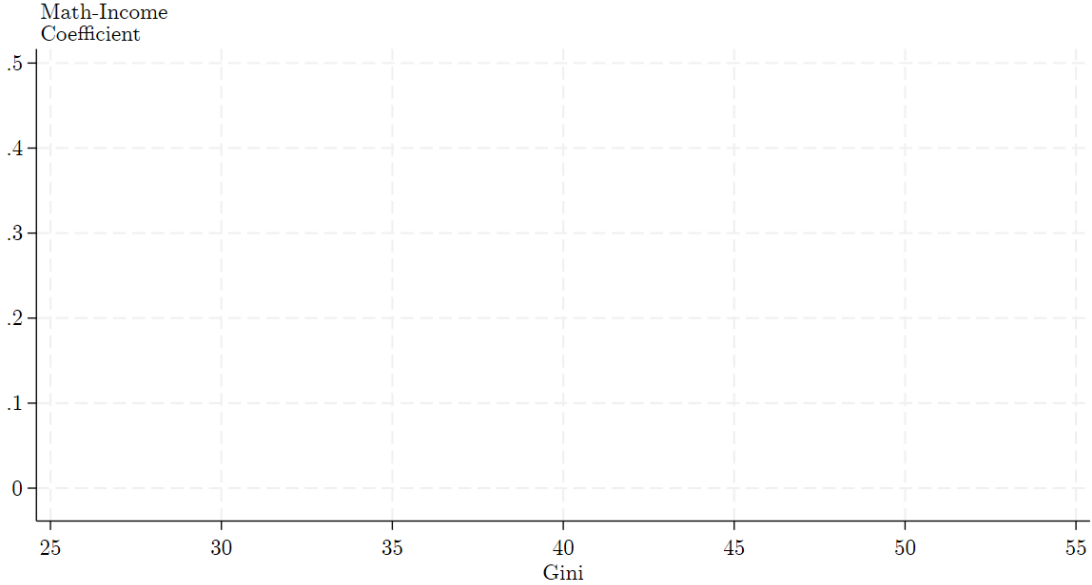
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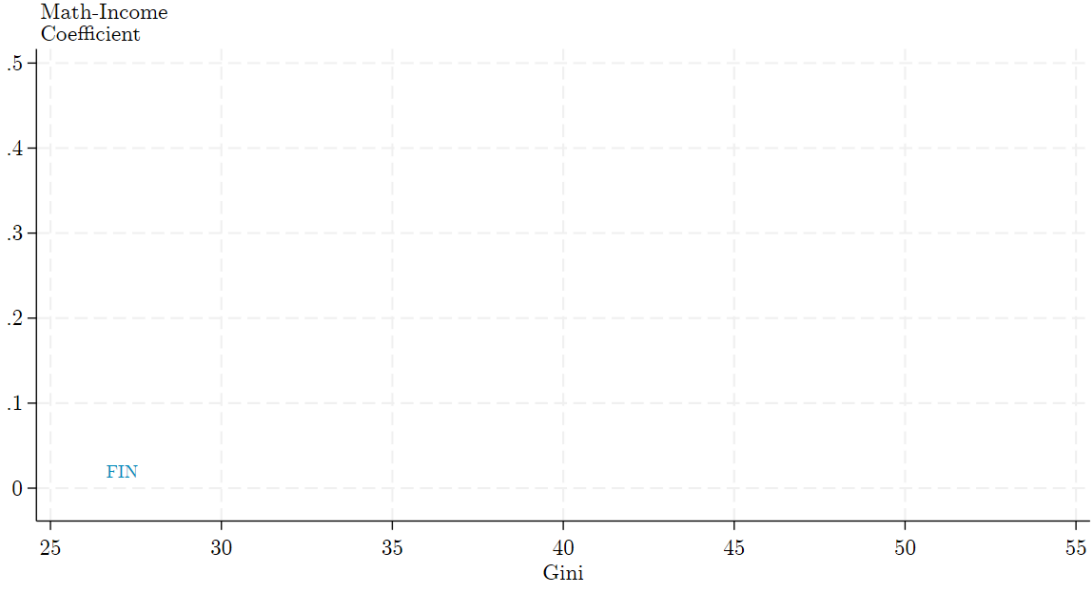
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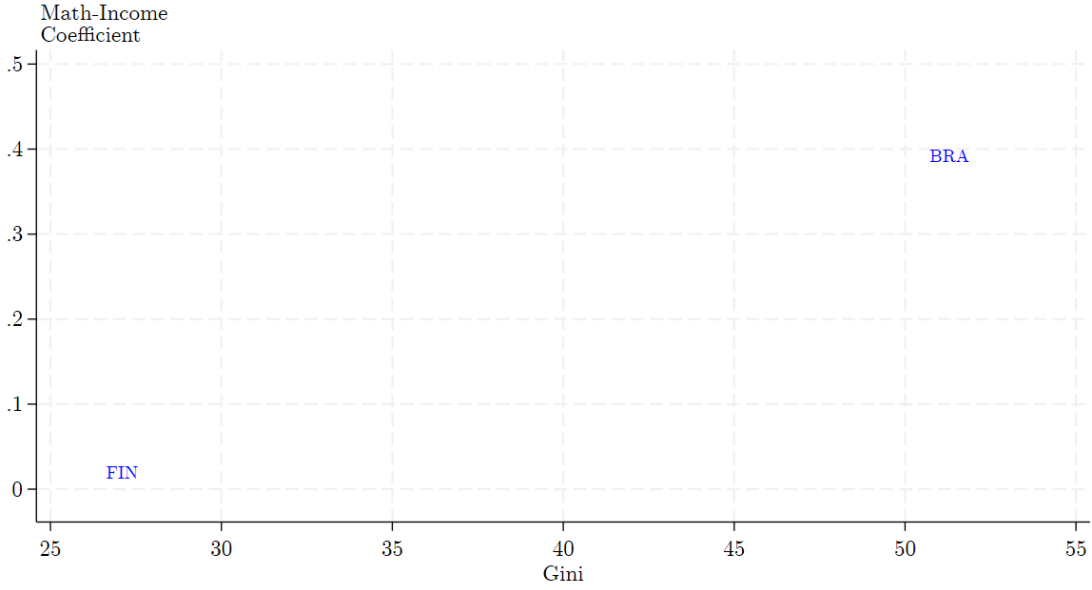
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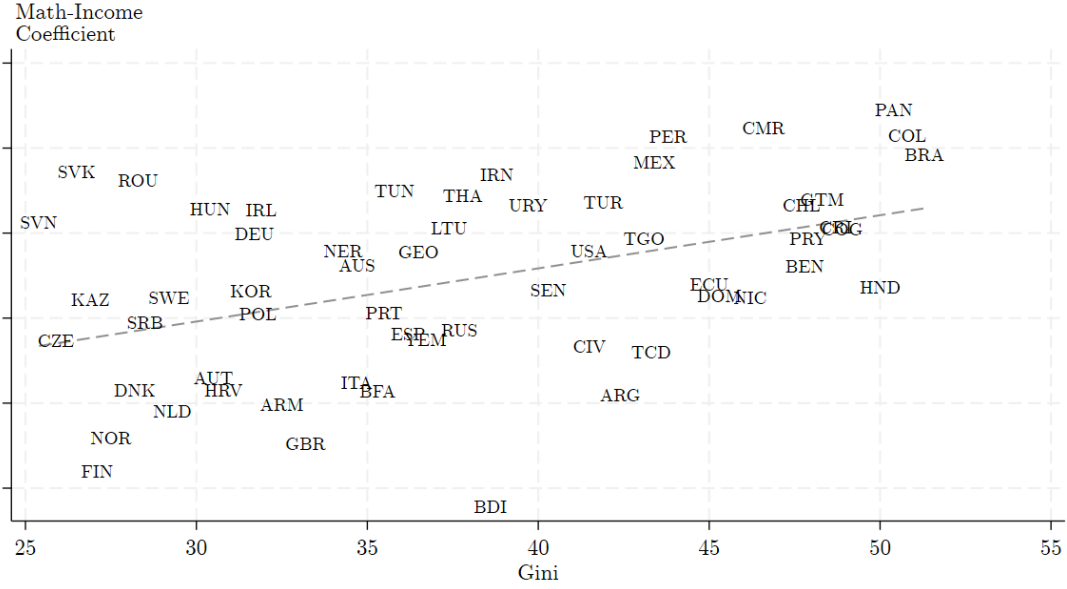
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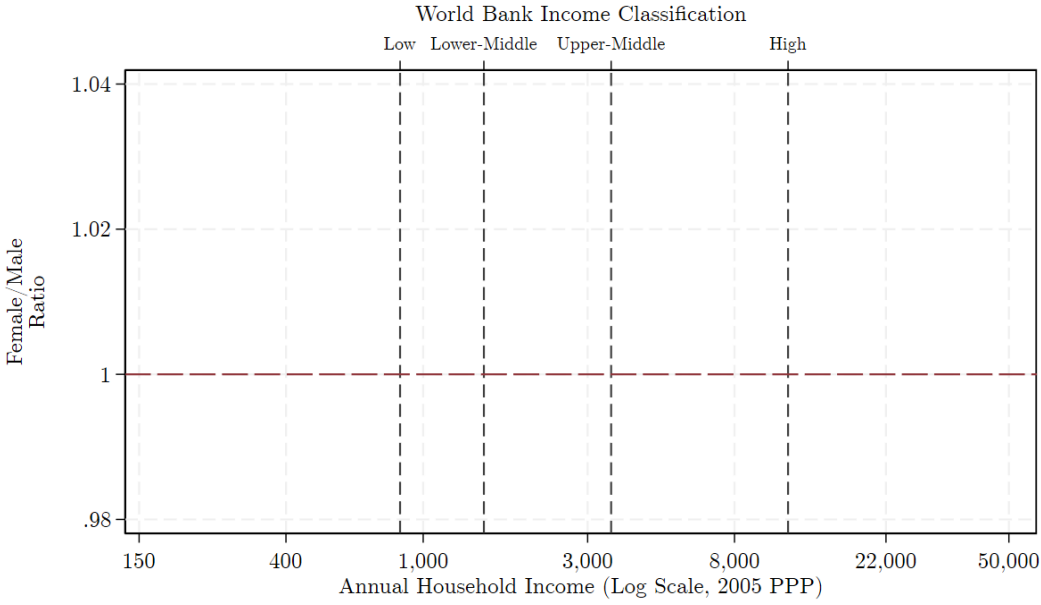
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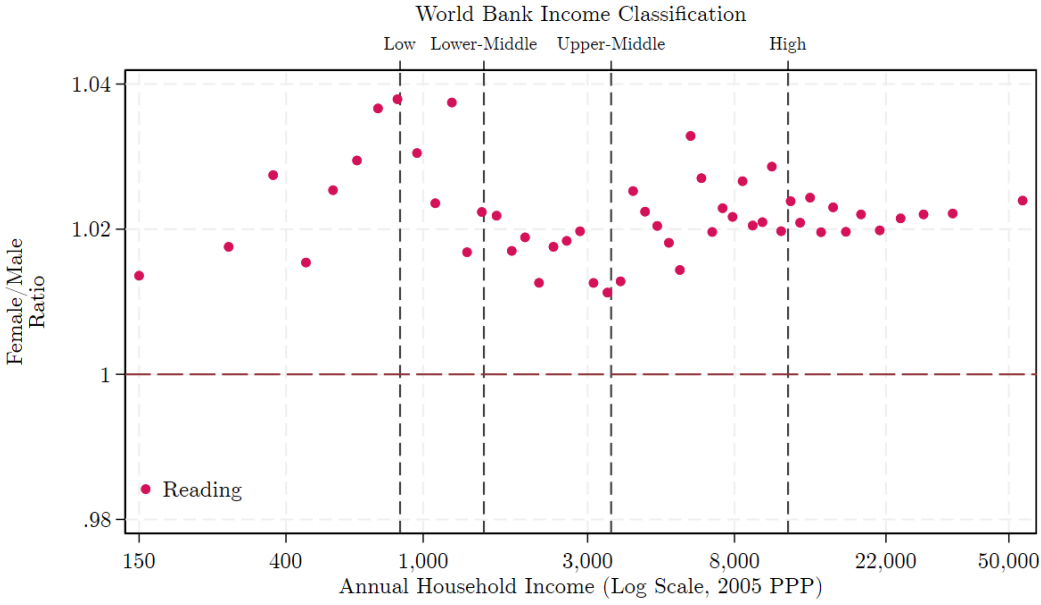
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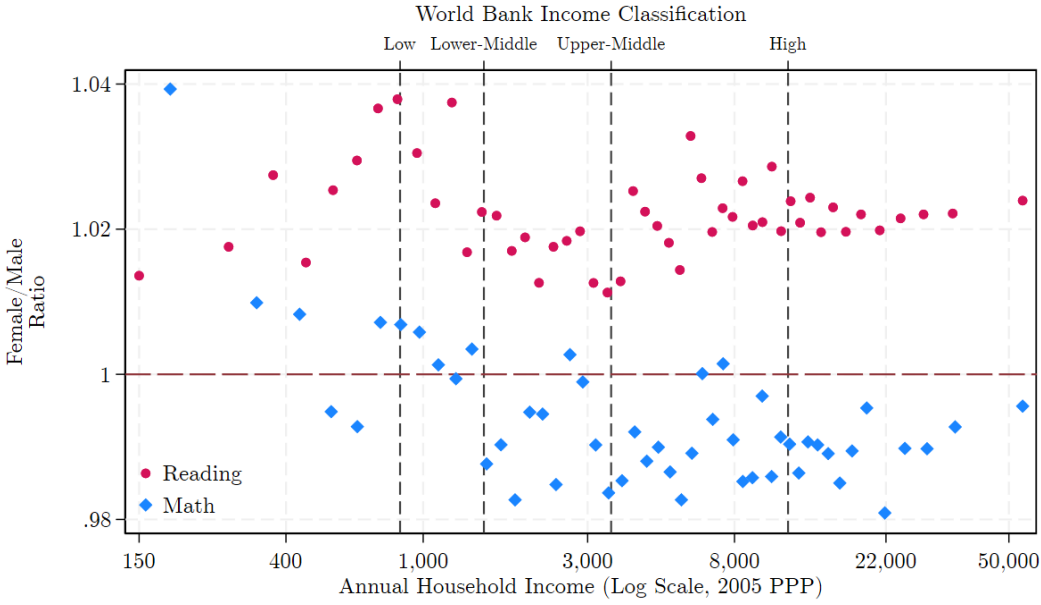
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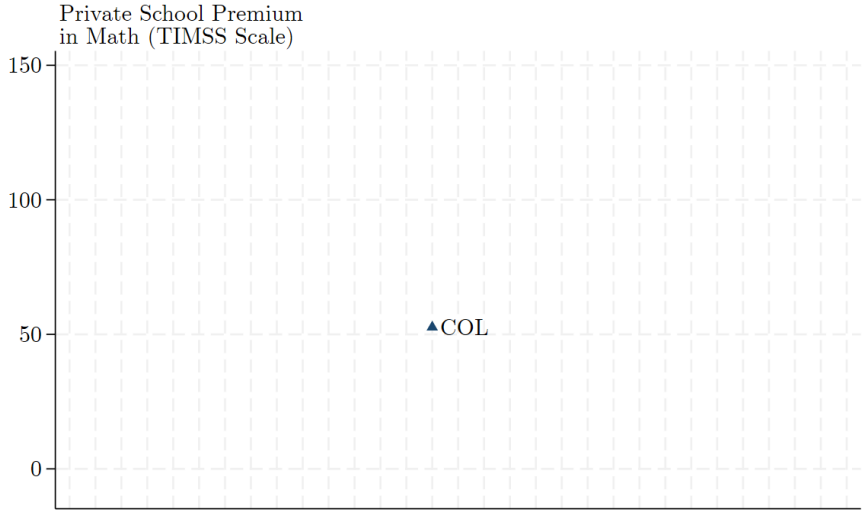
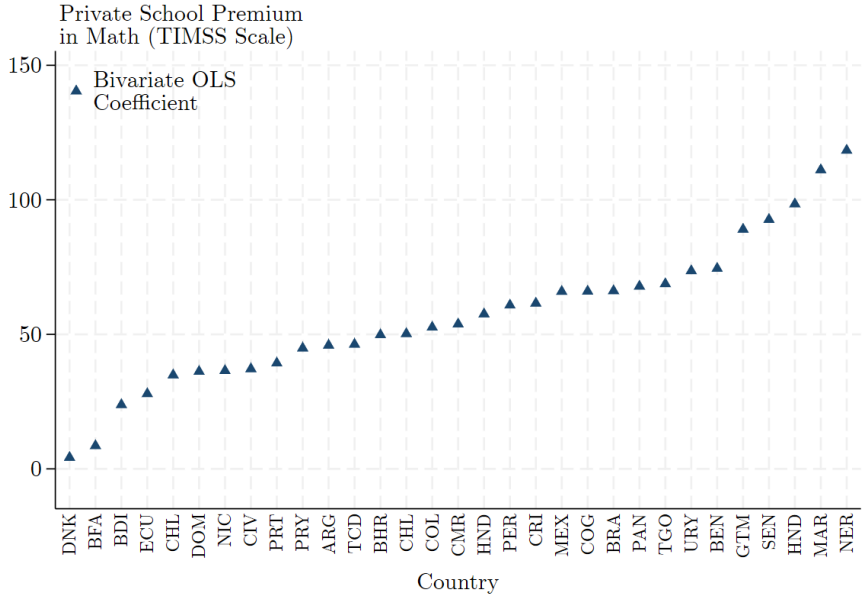

Private School Premium
in Math (TIMSS Scale)
150
100
50
0
COL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100
50
0
DNK
BFA
BDI
ECU
CHL
DOM
NIC
CIV
PRT
PRY
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TCD
BHR
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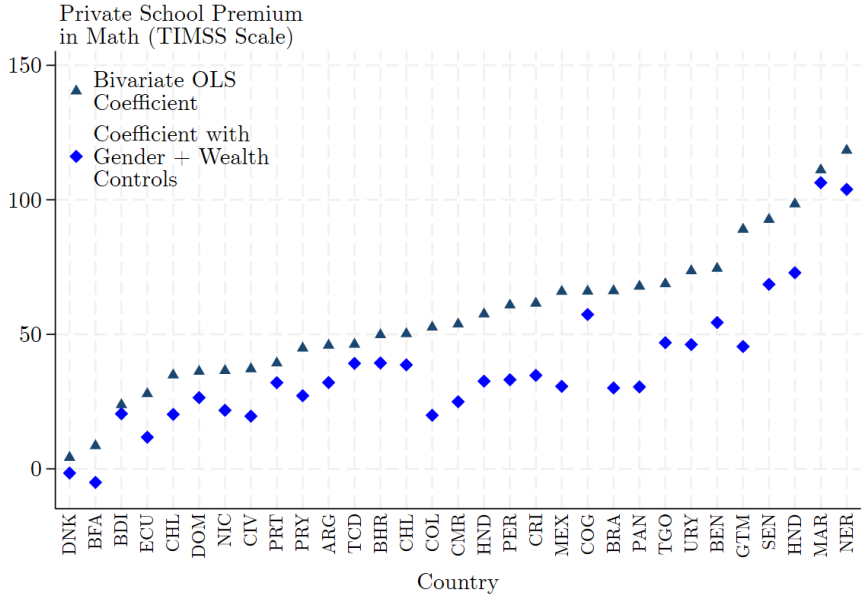
GTM
SEN
HND
MAR
NER
Country


Private School Premium
in Math (TIMSS Scale)
150
100
50
0
Bivariate OLS
Coefficient
Coefficient with
Gender + Wealth
Controls
DNK
BFA
BDI
ECU
CHL
DOM
NIC
CIV
PRT
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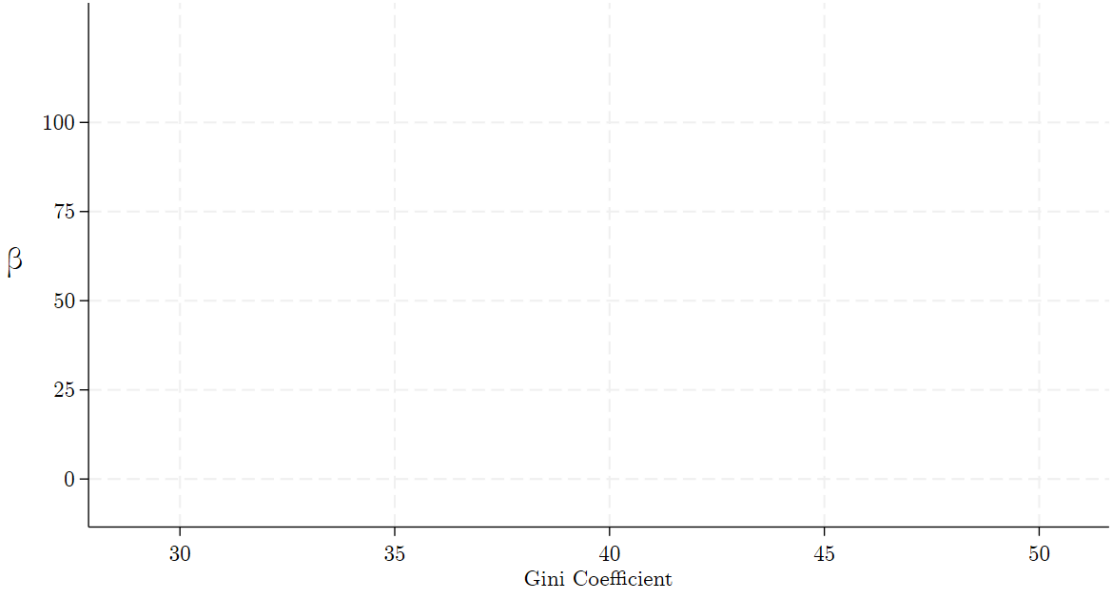
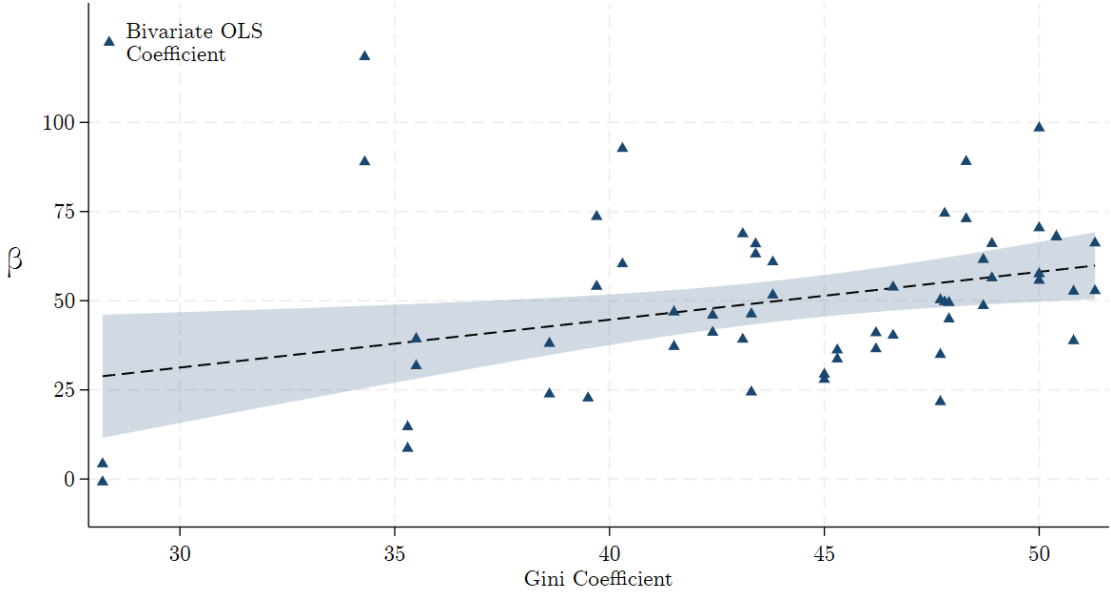
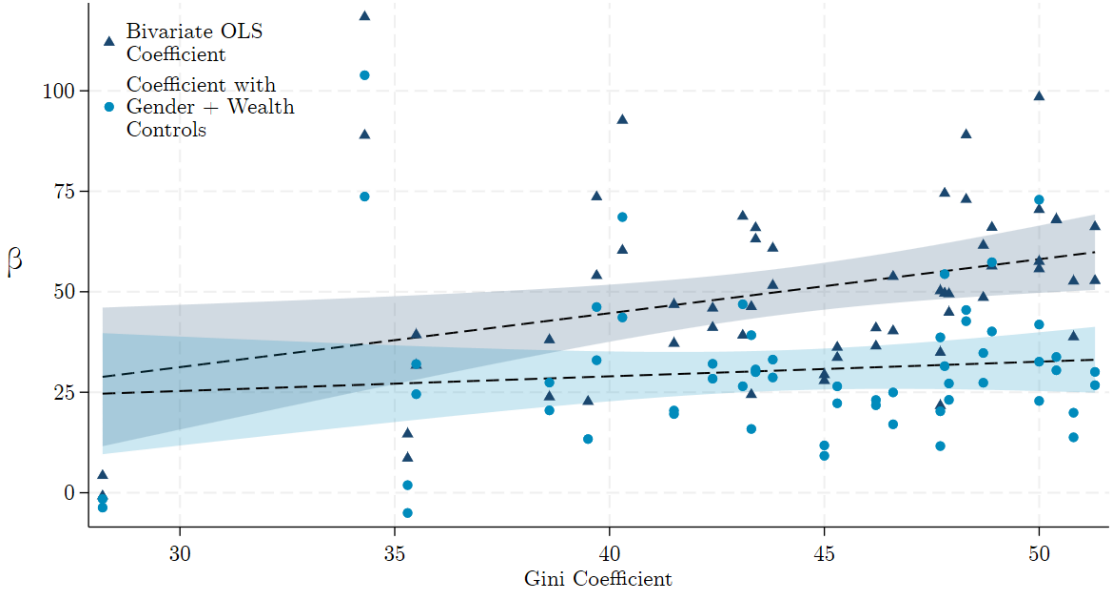

100
75
β
50
25
0
30
35
40
45
50
Gini Coefficient


Bivariate OLS
Coefficient
β
100
75
50
25
0
30
35
40
45
50
Gini Coefficient


Bivariate OLS Coefficient
Coefficient with Gender + Wealth Controls
β
100
75
50
25
0
30
35
40
45
50
Gini Coefficient

Conclusion

- Propose method to compare measures of ability elicited on different scales
- Apply to link microdata on primary student math and reading skills across 80 countries
- Large gaps exist between rich and poor countries *above and beyond* household income
- "Rosetta Stone" approach exhibits network externality

Thank you!

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Generalized Partial Credit Model

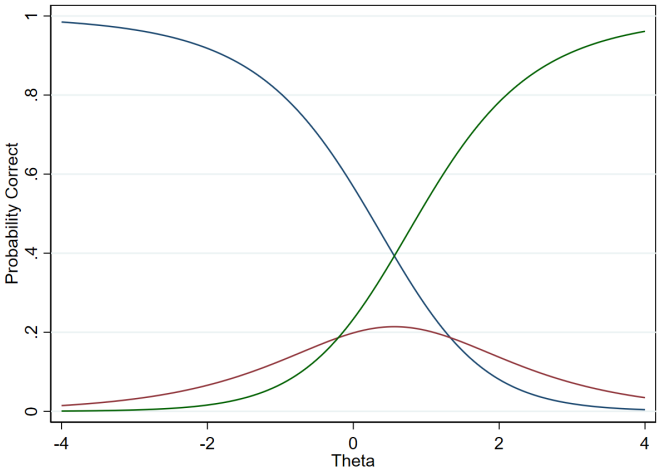
Back

For non-dichotomous items (partial credit), adopt general partial credit model:

$$P(x_{ij} = l|\theta_i, a_j, b_j, d_{j,1}, ..., d_{j,m_j-1}) =$$

$$\frac{\exp\left(\sum_{v=0}^{l} a_j\left(\theta_i - b_j + d_{j,v}\right)\right)}{\sum_{g=0}^{m_i-1}\exp\left(\sum_{v=0}^{g} a_j\left(\theta_i - b_j + d_{j,v}\right)\right)}$$

- Blue curve: 0 points
- Red curve: 1 point
- Green curve: 2 points



Data Collection in Bihar, India

Back

- Roughly 57 items per test
- Sample of 2,314 students in 51 schools across six districts in Bihar, India
- Grades 4-8, with a median age of 11
- 52.1 percent female

Data Collection in Florida, USA

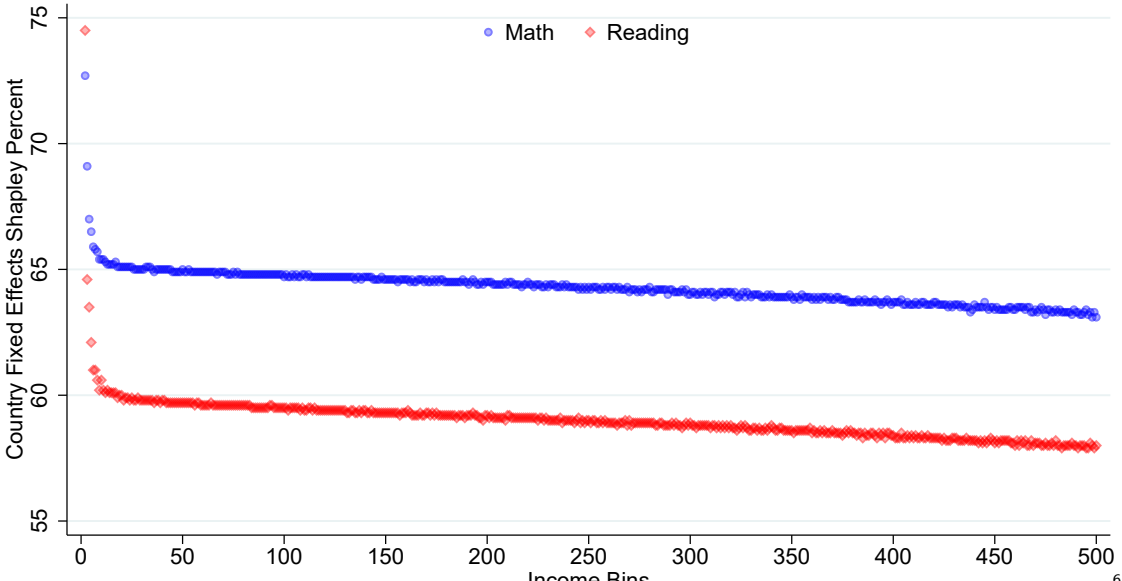
Back

- Partner with Character Labs Research Network
- Conducted online via a Qualtrics survey (most students took test at home due to COVID)
- Students randomized into either math or English
- Within subject, students randomized to questions, stratified by source test
- Much shorter than Bihar: 25 minutes

Symmetry Tests

Back

Variable	(1) Original N	(1) Original Mean/SE	(2) Converted Twice N	(2) Converted Twice Mean/SE	T-test P-value (1)-(2)
PASEC Math	2314	468.488 (1.955)	2313	468.559 (1.809)	0.979
PASEC Reading	2314	480.378 (2.084)	2314	480.791 (1.913)	0.884
LLECE Math	2314	688.897 (2.008)	2313	688.901 (1.886)	0.999
LLECE Reading	2314	652.112 (1.774)	2314	652.290 (1.719)	0.943


Math
Reading
Country Fixed Effects Shapley Percent
75
70
65
60
55
0
50
100
150
200
250
300
350
400
450
500
Income Bins

Relative Role of Country vs. Household Income

Back

Shapley decomposition of R^2

$$R_j^2 = \sum_{T \subseteq Z \ \{x_j\}} \frac{k!\,(p-k-1)!}{p!} \left[R^2(T \cup \{x_j\}) - R^2(T)\right]$$

T is model with k regressors except x_j, Z is fully saturated model