A model-based allocation approach for estimation of adult competency in small domains

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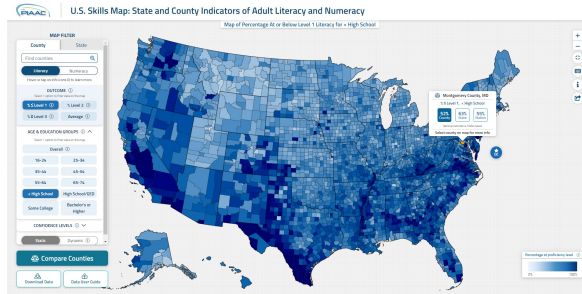
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Contribution: Official Statistics

Model-based domain-level literacy and numeracy estimates of average scores and at-level proportions

- ► Proficiency levels: At or Below Level 1 (0 - 225), At Level 2 (226 - 275), At or Above Level 3 (276 - 500)
- ► Domains: county/state x age/education group, county, state

Source: U.S. Skills Map: State and County Indicators of Adult Literacy and Numeracy [National Center for Education Statistics at the Institute of Education Sciences]

Contribution: Resources

Data

▶ Sparse survey sample at fine levels: 2012/2014/2017 U.S. Program for the International Assessment of Adult Competencies (PIAAC)

County-level sample summaries for age and education groups

Age/Education group	Number of counties* with sample data	Number of respondents		
		Minimum	Median	Maximum
16-24	172	1	10	82
25-34	177	1	11	96
35-44	180	1	9.5	56
45-54	178	1	10	72
55-64	180	1	10	45
65-74	176	1	6.5	31
Less than high school	175	1	8	67
High school diploma or GED	180	1	16	86
Some college	182	1	16	114
Bachelor's degree or higher	179	1	13	115

*There were 185 counties with sample data.

▶ Auxiliary information: American Community Survey (ACS)

Overview of the Modeling Process
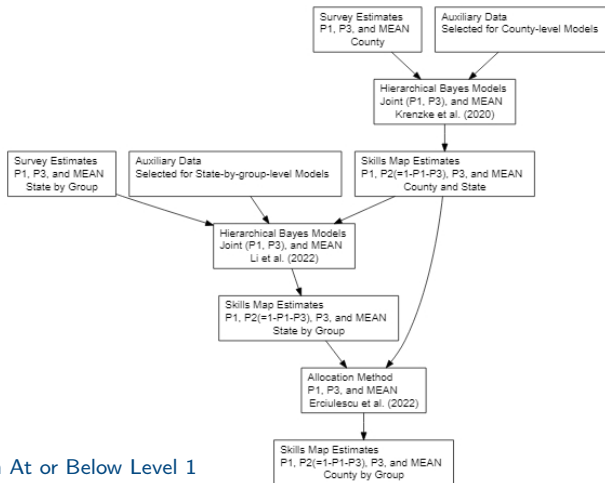
▶ P1 is the proportion At or Below Level 1
▶ P2 is the proportion At Level 2
▶ P3 is the proportion At or Above Level 3
▶ MEAN is the average score

Model-based Allocation

$$Y_{g,jk}^{(b)} := Y_{g,j}^{(b)} \frac{Y_{jk}^{(b)}}{Y_{j}^{(b)}}$$
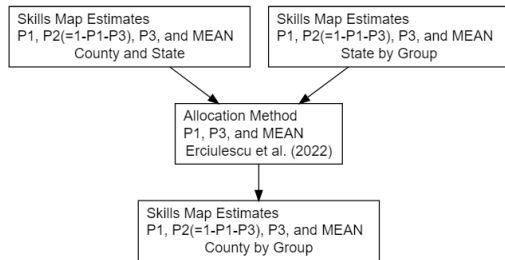
- $g = 1, ..., 10$ is an index for the age/education groups
- $j = 1, ..., 51$ is an index for the states
- $k = 1, ..., 3,142$ is an index for the counties
- $b = 1, ..., 4,500$ is an index for the posterior samples
- Y is either P1, P3, or MEAN
- $Y_{j}^{(b)}$, $Y_{jk}^{(b)}$, $Y_{g,j}^{(b)}$, $Y_{g,jk}^{(b)}$ are the posterior samples for the county, state, state-by-group, and county-by-group quantities, respectively

Selected Results: Shrinkage

Change in county-level estimates for literacy proportions of less than high school population
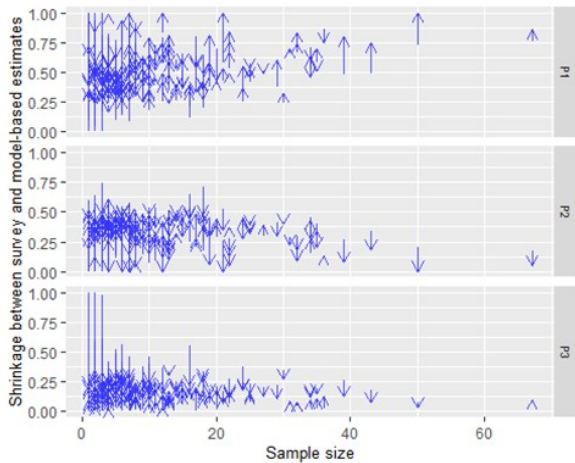
Selected Results: Comparability

County-level estimates for literacy proportions of less than high school population At or Below Level 1 versus ACS variables

Selected Results: Uncertainty

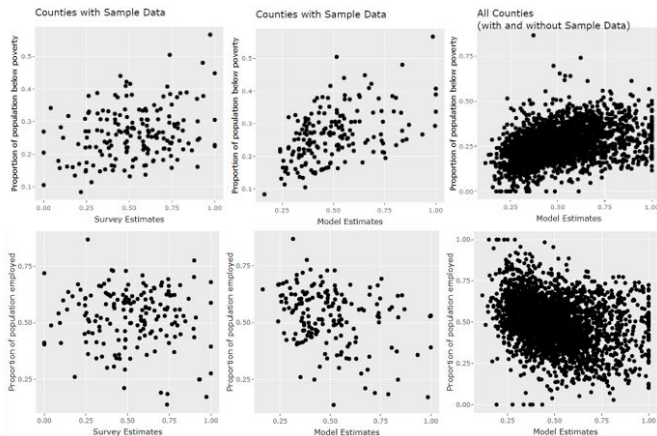Credible interval (CI) widths and coefficients of variation (CV) for county-level model-based estimates for At or Below Level 1 literacy proportion of less than high school population

Set of Domains / Metric	Percentile of Empirical Distribution				
	20	40	50	60	80
All domains					
95% CI width (%)	21.1	23.4	24.5	25.9	29.4
CV (%)	10.7	12.1	12.9	14.0	17.7
Domains with sample data					
95% CI width (%)	19.6	21.5	22.7	24.0	27.9
CV (%)	10.3	11.6	12.3	12.8	16.3
Domains without sample data					
95% CI width (%)	21.2	23.5	24.7	25.9	29.5
CV (%)	10.7	12.1	13.0	14.1	17.7

Summary

- ▶ Model-based estimation at fine levels of aggregation
  - ▶ county by group, in addition to previous developments at state, state by group, and county
    - ▶ implausible results carried over from county and state estimation
- ▶ Consistency across levels of aggregation
  - ▶ county by group as allocation of state by group according to county-to-state ratio
    - ▶ no benchmarking
- ▶ Precision
  - ▶ county by group coefficients of variation mostly below 20%
- ▶ Official statistics
  - ▶ Skills Map

Remark. Modeling at the unit level or at the lowest level of aggregation (e.g., county by group) would provide unified frameworks for constructing estimates at all levels of aggregation (e.g., county by group $\xrightarrow{\text{aggregation}}$ county $\xrightarrow{\text{aggregation}}$ state, and county by group $\xrightarrow{\text{aggregation}}$ state by group). However, such approaches would require reliable aggregation weights, covariates, or survey direct estimates, which may not be available in practice.

Selected references

Krenzke, T., Mohadjer, L., Li, J., Erciulescu, A., Fay, R., Ren, W., Van de Kerckhove, W., Li, L., and Rao, J.N.K. (2020). "Program for the International Assessment of Adult Competencies (PIAAC): State and County Estimation Methodology Report (NCES 2020-225)." U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office. Retrieved [10-26-2020] from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2020225.

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Thank you!

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Auxiliary Data Selected for County-level Models

Percentage of population ...

- ▶ age 25 and over with less than high school education
- ▶ age 25 and over with more than high school education
- ▶ below 100 percent of the poverty line
- ▶ Black or African American
- ▶ Hispanic
- ▶ civilian noninstitutionalized who has no health insurance coverage
- ▶ age 16 and over with service occupations

Auxiliary Data Selected for State-by-group-level Models: Education Groups

Percentage of population ...

- ▶ civilian noninstitutionalized who has no health insurance coverage
- ▶ below 100 percent of the poverty line
- ▶ age 16-24

Auxiliary Data Selected for State-by-group-level Models: Age Groups

Percentage of population ...

▶ with less than high school education
▶ with more than high school education
▶ below 100 percent of the poverty line
▶ age 16 and over with service occupations