

Continuing to Revise the Census Bureau's Low Response Score

Luke J. Larsen, Yazmin Garcia Trejo, Fane Lineback, Eric Jensen
U.S. Census Bureau

Prepared for the 2025 ACS Data Users Conference
May 29, 2025

Acknowledgements

Many thanks to the Census analysts who contributed to this stage of the LRS Revision project:

- Ralph Culver III
- Anthony Knapp
- Karlesha LeGrier
- Ana I. Sánchez-Rivera
- Faraz Shaikh
- Maxwell Hope
- Ian Le
- Earl Letourneau
- Steven Scheid

Disclaimer:

This presentation is released to inform interested parties of ongoing research and to encourage discussion of work in progress. The views expressed are those of the authors and not necessarily those of the U.S. Census Bureau. All data contained within are based upon publicly available data sources that have been reviewed in accordance with Census Bureau disclosure avoidance policies.

Today's Presentation

- Introduction (The What and Why of the Low Response Score)
- Methodology
- Analysis and Results
- Recommendation for 2020-based LRS model
- Next Steps

Introduction – The What and Why of the Low Response Score

What is the Low Response Score (LRS)?

Developed in early 2010s to predict 2020 Census mail non-response rates*

LRS is the *predicted rate of self non-response* to the Decennial Census

Based on OLS regression of 25 PDB metrics upon Census 2010 mail return rate

Values range from 0 to 100 percent (lower values are better)

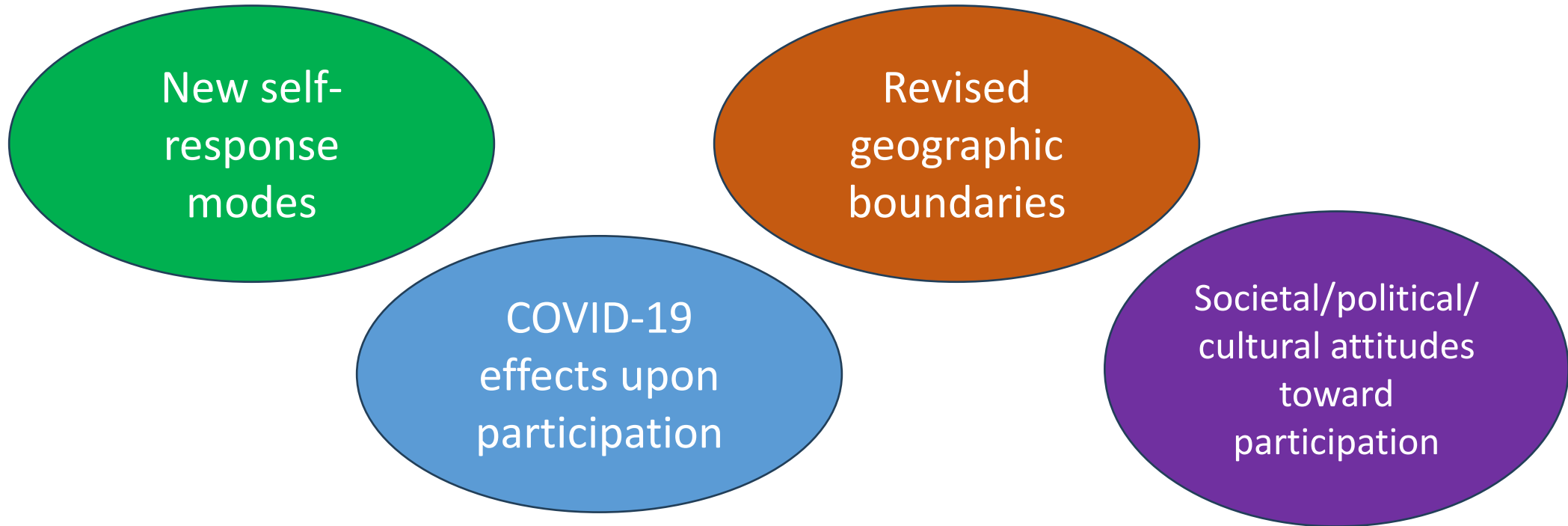
Produced at the Tract and Block-Group geographic levels

Updated annually with latest ACS 5-year estimates on the PDB

Last updated on 2021 PDB (final vintage with Census 2010 basis)

So, what's the problem?

2020 Census changed the landscape for the 2010-based LRS model



Revising the Low Response Score

- Prior to 2020, Census Bureau researchers formed a Working Group to:
 - Explore model improvement strategies
 - Obtain updated data inputs
 - Develop new predictive metrics
- Today, we highlight results of our efforts to update the Low Response Score model based on 2020 Census data.
- This is a first-pass effort to revise the LRS with “common sense, low-lift” modifications to expedite the new metric. More to come in later years!

Methodology – Global Modifications & Candidate Models

Global Modifications – the “must-do” list

- Response variable (RV) was Mail Return Rate, now Self Return Rate (all modes)
- Tract & BG definitions based on 2020 Census Tabulation Geographies
- Transformations of original 25 predictor variables have been re-adjusted
- Return rates are in percent-space, so the LRS ought to be bound between 0 and 100. To ensure this, we now apply a probit transform to the RV, then fit the model, then apply an inverse probit transform to the fitted values to obtain the LRS.
- One original Census-based predictor (percent of HUs with related children under age 6) was not published in the 2020 Census DHC file, so we replaced it with the ACS-based counterpart that was available on the Summary File.

New Predictors Under Consideration (1)

Seven Demographic/Socioeconomic/Housing Variables on the PDB:

- Percent HUs with **no internet access** (ACS)
- Percent HUs with **smartphone as only** source of internet (ACS)
- Percent HUs that are **mobile homes** (ACS)
- Percent HUs with **no phone service** (ACS)
- Percent occupied HUs that are “**crowded**”* (ACS)
- Percent of Pop age 5+ that speaks **language other than English** at home (ACS)
- Percent of Pop that **lives in group quarters** (Census)

** Defined as Housing Units (HUs) in which the person-to-room ratio is greater than 1.*

New Predictors Under Consideration (2)

2020 Census Contact Strategy

- HUs were pre-assigned to one of two initial contact strategies (CS):
 - “Internet First”: HUs were prompted only toward Internet mode at first contact
 - “Internet Choice”: HUs were offered choice of response modes at first contact
- Assignment of CS was universal across entire tracts (based on 2010 definitions), determined in part by each tract’s Type of Enumeration Area (TEA) classification.
- Under 2020 tract/BG definitions, it’s possible for some geographies to have a mix of HUs assigned to either CS.
- Two percentage variables that completely describe the CS assignment information for tracts and block groups are candidates for the revised LRS model.
- ***Note: CS assignment data are not currently publicly available – we are working on getting these cleared for release on the PDB!***

New Predictors Under Consideration (3)

Geographic Interactions with Main-Effect Predictors

- The 2010-based LRS does not account for regional variation.
- Considering two levels of interactions: Census Divisions (9) and States (51)
- Indicator flag = 1 if the tract/BG is in Geography X, otherwise flag = 0.
- Cross each main-effect predictor with each flag to represent interactions.
 - Division models: up to $8 \times 34 = 272$ interaction terms in the model
 - State models: up to $50 \times 32^* = 1600$ interaction terms in the model

** The CS variables combined with state indicators caused full-rank issues in the state-level regression models, so those interactions were removed from the ST2 and ST3 candidates.*

Candidate Regression Models

Main Effects	Interactions		
	None	Division	State
Baseline (25 Original Vars)	ME0	DV0	ST0
Baseline + 7 New Variables	ME1	DV1	ST1
Baseline + Contact Strategy	ME2	DV2	ST2
Baseline + New Vars + CS	ME3	DV3	ST3

Saturated/Full Models
– includes all variables!

Analysis and Results

Model fit statistics, residuals, fitted values of Tract-level OLS regression models
(Block Group model results are comparable, but not shown here)

Summary of Selected Model Fit Statistics (Tract)

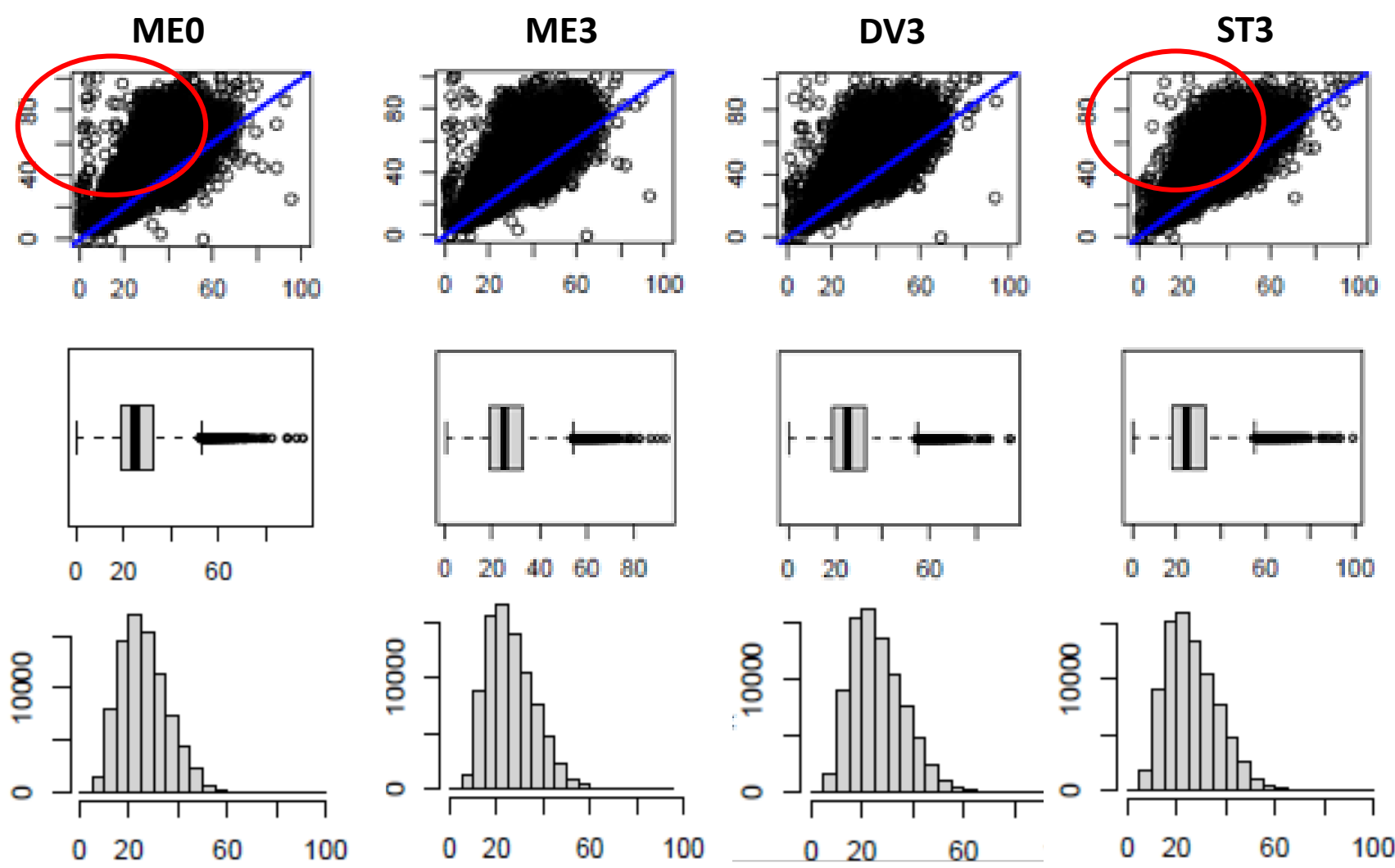
Model	DF(model)	MSE	F-value	P-value	R-Square
ME0 (baseline)	25	0.0347	9305.59	<0.0001	0.7365
ME3	34	0.0291	9781.45	<0.0001	0.7790
DV3	305	0.0246	1187.27	<0.0001	0.8136
ST3	1634	0.0232	218.36	<0.0001	0.8270

Source: U.S. Census Bureau, 2022 Planning Database, 2020 Census Contact Strategy data. N \approx 83,000 tracts.

We conducted F-tests between each model's output to gauge significance of improved performance (adjusted for multiple comparisons). In each step up in model complexity, the model-fit improvement was found to be statistically significant ($\alpha = 0.10$).

The R-squares demonstrate how explained variance in self-return rates improves from the baseline to each of the saturated models (ME3, DV3, ST3). Notably, the 2010-based tract-level LRS model had an R-square of around 0.55, so these results appear to show a remarkable shift in explanatory power with the new models.

Selected Fitted Value Analysis - 1 (Tract)



Scatterplots
(Fitted vs
Response)

Boxplots

Histograms

Selected Fitted Value Analysis - 2 (Tract)

Model	Mean LRS	Median	Std Dev	Min	Max
ME0	26.212	25.104	9.798	0.346	95.440
ME3	26.256	24.757	10.188	0.571	93.194
DV3	26.300	24.776	10.416	0.151	94.166
ST3	26.330	24.805	10.594	0.161	99.203

Source: U.S. Census Bureau, 2022 Planning Database, 2020 Census Contact Strategy data. N \approx 83,000 tracts.

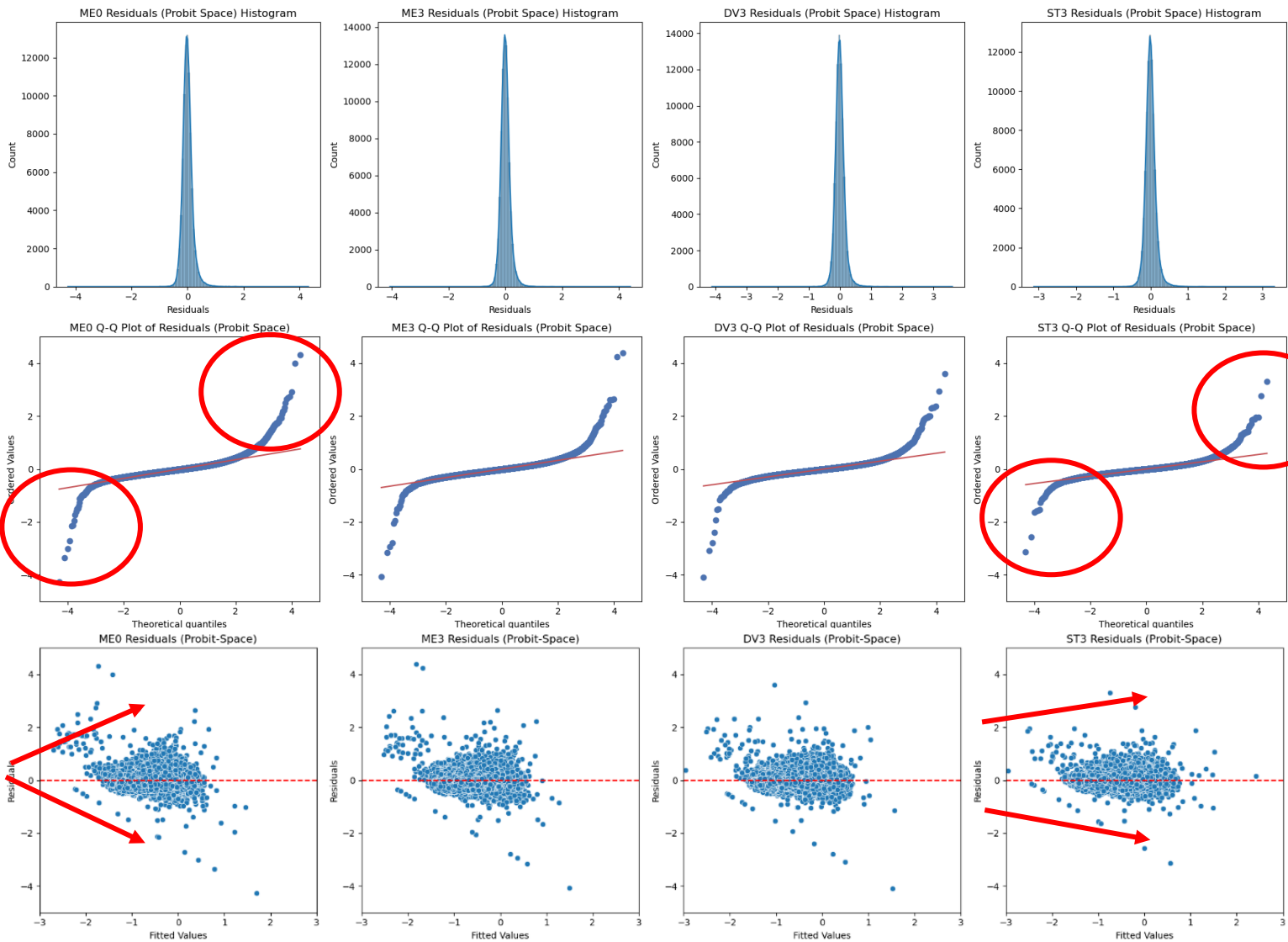
Selected Residual Analysis – 1 (Tract)

ME0

ME3

DV3

ST3



Histograms

Q-Q Plots

Scatterplots
(Fitted vs
Residual)

Selected Residual Analysis - 2 (Tract)

Model	Mean Residual	Std Dev	Skewness	Kurtosis
ME0	0.257	6.084	1.433	11.085
ME3	0.213	5.484	1.180	11.972
DV3	0.173	5.052	1.185	12.373
ST3	0.140	4.661	1.168	10.025

Source: U.S. Census Bureau, 2022 Planning Database, 2020 Census Contact Strategy data. N ≈ 83,000 tracts.

Overall findings

- Of all candidates, the **saturated state-interaction model (ST3)** had the best model fit relative to the baseline model (ME0)
- Resulting fitted values (the LRS) behave much more like the Census 2020 Self-Return Rates under ST3 than under the other candidates.
- Residuals under ST3 trend toward normality more so than other candidates and are generally smaller in magnitude.
- Findings* are consistent when examining LRS output by divisions, by states, by relative population size, and by contact strategy.

** Not shown today*

Recommendation / Next Steps

Recommendation

The Workgroup recommends that the **saturated state-interaction model (ST3)** is optimal over other candidate models and should form the basis for the 2020-based Low Response Score.

- *Though it has a more complex structure than the other candidates, the ST3 model featured significantly better model fit with improved residuals.*

The forthcoming working paper will reflect similar findings for block-group data and showcase improved performance trends among regional and state collections of tracts and block groups.

Next Steps

- **Complete analysis of LRS predicted values** under candidate models to finalize model recommendation
- **Investigate sampling error concerns** (requested by M&S Council)
- **Prepare recommendation memorandum** to Decennial for approval
- Work with PDB production team to **publish LRS on the 2024 PDB**
- **Continue R&D** into other LRS data products:
 - State-specific LRS models (including an LRS for Puerto Rico)
 - Variance estimates for the LRS
 - ...and more!

Questions, Comments, Concerns?

Luke.J.Larsen@census.gov