

**Development Research at High Geographic Resolution:  
An Analysis of Night Lights, Firms, and Poverty in India  
using the SHRUG Open Data Platform**

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Online Appendix: Additional Tables and Figures

**Table S1**  
Population Share Matched to the SHRUG, by State

States	PC91	PC01	PC11
India	826117.89 / 833122.68 (99%)	1028120.50 / 1028349.73 (100%)	1209944.68 / 1210741.69 (100%)
Andaman Nicobar Islands	280.66 / 280.66 (100%)	356.15 / 356.15 (100%)	380.55 / 380.58 (100%)
Andhra Pradesh	65140.70 / 66455.27 (98%)	76210.01 / 76210.01 (100%)	84580.78 / 84580.78 (100%)
Arunachal Pradesh	621.18 / 637.04 (98%)	1097.97 / 1097.97 (100%)	1383.17 / 1383.73 (100%)
Assam	22278.90 / 22311.78 (100%)	26640.04 / 26655.53 (100%)	30999.61 / 31205.58 (99%)
Bihar	86119.25 / 86374.47 (100%)	82825.55 / 82825.55 (100%)	104099.45 / 104099.46 (100%)
Chandigarh	642.01 / 642.01 (100%)	900.63 / 900.63 (100%)	1055.45 / 1055.45 (100%)
Chhattisgarh		20827.74 / 20833.80 (100%)	25544.25 / 25545.20 (100%)
Dadra Nagar Haveli	138.48 / 138.48 (100%)	220.49 / 220.49 (100%)	343.71 / 343.71 (100%)
Daman & Diu	101.59 / 101.59 (100%)	158.20 / 158.20 (100%)	243.25 / 243.25 (100%)
Goa	1155.51 / 1169.79 (99%)	1347.67 / 1347.67 (100%)	1458.55 / 1458.55 (100%)
Gujarat	41284.77 / 41309.58 (100%)	50671.02 / 50671.02 (100%)	60439.69 / 60439.69 (100%)
Haryana	16285.72 / 16459.98 (99%)	21139.38 / 21144.56 (100%)	25193.50 / 25351.46 (99%)
Himachal Pradesh	5165.07 / 5170.53 (100%)	6077.90 / 6077.90 (100%)	6864.45 / 6864.60 (100%)
Jammu Kashmir		10142.76 / 10143.70 (100%)	12539.86 / 12541.30 (100%)
Jharkhand		26945.83 / 26945.83 (100%)	32983.76 / 32988.13 (100%)
Karnataka	44663.16 / 44977.20 (99%)	52785.20 / 52850.56 (100%)	61032.42 / 61095.30 (100%)
Kerala	28631.18 / 29098.52 (98%)	31841.37 / 31841.37 (100%)	33406.06 / 33406.06 (100%)
Lakshadweep	51.71 / 51.71 (100%)	60.65 / 60.65 (100%)	64.47 / 64.47 (100%)
Madhya Pradesh	62281.73 / 63026.21 (99%)	60345.27 / 60348.03 (100%)	72626.81 / 72626.81 (100%)
Maharashtra	78363.48 / 78936.42 (99%)	96878.63 / 96878.63 (100%)	112323.51 / 112374.34 (100%)
Manipur	1806.38 / 1837.15 (98%)	2166.79 / 2166.79 (100%)	2851.43 / 2855.79 (100%)
Meghalaya	1764.66 / 1774.74 (99%)	2288.95 / 2318.82 (99%)	2961.91 / 2966.89 (100%)
Mizoram	689.54 / 689.76 (100%)	888.57 / 888.57 (100%)	1094.51 / 1097.21 (100%)
Nagaland	1207.14 / 1209.55 (100%)	1989.66 / 1990.04 (100%)	1978.50 / 1978.50 (100%)
NCT of Delhi	9420.64 / 9420.64 (100%)	13850.51 / 13850.51 (100%)	16787.94 / 16787.94 (100%)
Odisha	31515.51 / 31587.64 (100%)	36799.75 / 36804.66 (100%)	41945.54 / 41969.76 (100%)
Puducherry	771.56 / 807.78 (96%)	974.35 / 974.35 (100%)	1247.95 / 1247.95 (100%)
Punjab	19053.16 / 19053.16 (100%)	24334.90 / 24359.00 (100%)	27650.20 / 27743.34 (100%)
Rajasthan	43354.10 / 43879.50 (99%)	56502.28 / 56507.19 (100%)	68548.43 / 68548.44 (100%)
Sikkim	405.02 / 405.02 (100%)	540.85 / 540.85 (100%)	610.57 / 610.58 (100%)
Tamil Nadu	55111.89 / 55834.15 (99%)	62367.39 / 62405.68 (100%)	72117.59 / 72147.03 (100%)
Tripura	2430.67 / 2757.20 (88%)	3198.93 / 3199.20 (100%)	3666.08 / 3673.92 (100%)
Uttarakhand		166186.02 / 166197.92 (100%)	199763.41 / 199812.34 (100%)
Uttar Pradesh	138452.58 / 138837.84 (100%)	8479.34 / 8489.35 (100%)	10071.41 / 10086.29 (100%)
West Bengal	66929.92 / 67887.31 (99%)	80079.76 / 80088.56 (100%)	91085.92 / 91167.27 (100%)

*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.

*Note:* Table S1 presents the state-level population included in the SHRUG panel (numerator), the state-level population in the Population Census datasets (denominator), and the share of state-level population captured by the SHRUG, for all states and union territories in India. Population numbers are reported in thousands. Chhattisgarh, Jharkhand, and Uttarakhand were created in 2000 and are thus left blank in earlier years.

**Table S2**  
Employment Share Matched to the SHRUG, by State

States	EC90	EC98	EC05	EC13
India	43266.88 / 62211.08 (70%)	62851.43 / 70891.77 (89%)	79038.38 / 85388.85 (93%)	107639.65 / 110513.80 (97%)
Andaman Nicobar Islands	12.27 / 31.14 (39%)	48.32 / 48.32 (100%)	17.00 / 39.05 (44%)	61.09 / 61.21 (100%)
Andhra Pradesh	4080.46 / 5263.04 (78%)	5742.84 / 6243.11 (92%)	8568.18 / 8991.79 (95%)	10492.67 / 11563.89 (91%)
Arunachal Pradesh	13.00 / 61.86 (21%)	48.80 / 54.68 (89%)	64.96 / 81.30 (80%)	89.80 / 108.38 (83%)
Assam	994.49 / 1265.52 (79%)	1626.39 / 1914.82 (85%)	1731.44 / 2037.68 (85%)	3606.55 / 3665.87 (98%)
Bihar	2467.22 / 2915.64 (85%)	1715.85 / 2028.94 (85%)	2031.13 / 2096.17 (97%)	2929.19 / 3116.34 (94%)
Chandigarh	137.46 / 137.46 (100%)	148.16 / 148.16 (100%)	185.33 / 185.33 (100%)	244.27 / 244.27 (100%)
Chhattisgarh		1003.77 / 1154.32 (87%)	1154.25 / 1377.39 (84%)	1800.44 / 1834.96 (98%)
Dadra Nagar Haveli	13.23 / 13.23 (100%)	27.36 / 31.04 (88%)	64.61 / 64.61 (100%)	94.31 / 94.31 (100%)
Daman & Diu	18.55 / 18.55 (100%)	29.80 / 29.86 (100%)	59.84 / 59.84 (100%)	81.42 / 81.42 (100%)
Goa	87.27 / 169.84 (51%)	153.98 / 191.81 (80%)	187.36 / 208.13 (90%)	284.58 / 284.92 (100%)
Gujarat	2287.73 / 2831.85 (81%)	3676.17 / 3779.33 (97%)	3957.48 / 4412.87 (90%)	6143.60 / 6246.70 (98%)
Haryana	939.56 / 1190.77 (79%)	1052.97 / 1408.53 (75%)	1742.25 / 1950.83 (89%)	2811.10 / 2845.80 (99%)
Himachal Pradesh	324.97 / 357.05 (91%)	446.01 / 461.38 (97%)	543.54 / 552.25 (98%)	894.05 / 938.60 (95%)
Jammu Kashmir		100.83 / 430.17 (23%)	546.40 / 645.96 (85%)	1043.19 / 1065.65 (98%)
Jharkhand		866.09 / 947.85 (91%)	991.34 / 1030.31 (96%)	1377.32 / 1386.44 (99%)
Karnataka	3571.51 / 6339.23 (56%)	4069.62 / 4228.16 (96%)	5035.00 / 5165.28 (97%)	5790.34 / 5829.52 (99%)
Kerala	2223.42 / 2961.80 (75%)	585.07 / 3249.12 (18%)	2931.26 / 4309.21 (68%)	5649.97 / 5701.44 (99%)
Lakshadweep		5.87 / 12.18 (48%)	8.37 / 8.37 (100%)	9.92 / 10.24 (97%)
Madhya Pradesh	2867.56 / 3190.24 (90%)	3142.60 / 3325.93 (94%)	3274.40 / 3531.72 (93%)	4086.12 / 4241.05 (96%)
Maharashtra	7187.69 / 7577.37 (95%)	8134.96 / 8381.88 (97%)	9036.32 / 9526.52 (95%)	11797.80 / 11947.80 (99%)
Manipur	9.93 / 133.45 (7%)	109.61 / 167.68 (65%)	147.97 / 204.65 (72%)	353.88 / 385.92 (92%)
Meghalaya	30.52 / 126.71 (24%)	133.20 / 144.36 (92%)	179.10 / 194.70 (92%)	269.67 / 277.45 (97%)
Mizoram	46.78 / 49.23 (95%)	46.98 / 52.25 (90%)	68.40 / 70.18 (97%)	93.97 / 101.05 (93%)
Nagaland	3.67 / 98.66 (4%)	92.67 / 95.23 (97%)	114.70 / 115.90 (99%)	157.44 / 159.77 (99%)
NCT of Delhi	1860.30 / 1860.30 (100%)	3331.36 / 3331.36 (100%)	3387.83 / 3387.83 (100%)	3003.82 / 3003.82 (100%)
Odisha	738.33 / 2205.11 (33%)	1842.30 / 2738.37 (67%)	3312.57 / 3355.95 (99%)	3891.08 / 4051.32 (96%)
Puducherry	84.80 / 104.51 (81%)	143.85 / 155.09 (93%)	101.85 / 165.52 (62%)	211.31 / 213.67 (99%)
Punjab	1210.66 / 1555.16 (78%)	1844.14 / 1914.10 (96%)	2366.73 / 2399.82 (99%)	3125.31 / 3139.81 (100%)
Rajasthan	1745.15 / 2203.52 (79%)	2687.16 / 2885.55 (93%)	3288.03 / 3569.26 (92%)	4897.19 / 5165.42 (95%)
Sikkim	18.00 / 35.24 (51%)	15.69 / 33.56 (47%)	6.39 / 48.67 (13%)	84.61 / 84.65 (100%)
Tamil Nadu	976.67 / 5266.63 (19%)	5842.72 / 6377.40 (92%)	6903.60 / 8052.45 (86%)	8718.60 / 8812.22 (99%)
Tripura	0.00 / 203.84 (0%)	148.40 / 218.62 (68%)	258.37 / 324.29 (80%)	379.29 / 382.24 (99%)
Uttarakhand		354.44 / 448.05 (79%)	7249.33 / 7328.97 (99%)	11377.23 / 11422.24 (100%)
Uttar Pradesh	5406.84 / 7505.02 (72%)	6045.04 / 6283.58 (96%)	564.74 / 619.01 (91%)	800.46 / 980.15 (82%)
West Bengal	3908.86 / 6539.10 (60%)	7588.40 / 7976.98 (95%)	8958.33 / 9277.06 (97%)	10988.06 / 11065.24 (99%)

*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.

*Note:* Table S2 presents the state-level employment included in the SHRUG panel (numerator), the state-level employment in the Economic Census datasets (denominator), and the share of state-level employment captured by the SHRUG, for all states and union territories in India. Employment numbers are reported in thousands. Chhattisgarh, Jharkhand, and Uttarakhand were created in 2000 and are thus left blank in earlier years.

**Table S3**  
**Asset Decomposition of Small Area Consumption Estimates:**  
**Rural Households**

	(1)	(2)	(3)	(4)	(5)
	IHDS	SECC	Difference	Coefficient	Delta
Income 5000-10,000 Rs	0.12	0.18	0.06	10076.33	590.07
Income Above 10,000 Rs	0.06	0.09	0.03	38933.33	1100.99
Home Ownership	0.99	0.95	-0.04	-1334.48	55.42
Kisan Credit Card	0.07	0.04	-0.03	12441.10	-388.38
Land Ownership	0.61	0.44	-0.17	9657.24	-1613.72
Number of Rooms in Home	2.60	2.15	-0.45	3428.70	-1549.51
Both Mobile and Landline	0.03	0.03	-0.00	31479.48	-86.19
Landline Phone	0.01	0.01	0.00	24639.32	15.93
Mobile Phone	0.68	0.69	0.01	23997.18	339.78
Refrigerator	0.11	0.12	0.01	29476.68	363.90
Brick Roof	0.05	0.07	0.02	-9604.72	-235.39
Concrete Roof	0.12	0.22	0.10	1431.76	149.18
GI Roof	0.16	0.14	-0.02	-3359.10	65.99
Grass Roof	0.23	0.16	-0.07	-2919.61	212.58
Plastic Roof	0.00	0.02	0.02	6473.79	110.06
Slate Roof	0.05	0.04	-0.01	2316.43	-34.52
Stone Roof	0.08	0.05	-0.03	11637.33	-341.08
Tile Roof	0.12	0.28	0.16	-6508.29	-1068.59
Four Wheeled Vehicle	0.02	0.03	0.01	85685.73	532.55
Two Wheeled Vehicle	0.17	0.18	0.01	34253.34	501.96
Brick Walls	0.27	0.43	0.16	23029.78	3703.36
Concrete Walls	0.24	0.04	-0.20	22316.29	-4512.30
GI Walls	0.01	0.01	-0.00	14184.44	-27.89
Grass Walls	0.07	0.11	0.04	12808.09	531.28
Mud Walls	0.33	0.27	-0.06	13371.95	-772.25
Plastic Walls	0.00	0.01	0.01	19748.41	128.43
Stone Walls	0.05	0.11	0.06	17065.06	1066.39
Wooden Walls	0.01	0.01	0.00	9216.71	15.00

*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.

*Note:* Table S3 presents a comparison of IHDS and SECC covariates that were used to generate per capita consumption small area estimates in the rural SHRUG. The IHDS and SECC columns indicate the value for each covariate in the SECC and IHDS surveys taken at the village level; because the SECC is a census, no weights were required, while the IHDS required the use of sampling weights. Column 3 presents the difference between the two. Column 4 shows the coefficient for each covariate when regressing per capita consumption on the set of covariates in the IHDS. Column 5 multiplies column 4 by column 3, representing the expected difference in per capita consumption between IHDS and SHRUG that is explained by that covariate. The omitted category for roof and wall materials was "other."

**Table S4**  
**Asset Decomposition of Small Area Consumption Estimates:**  
**Urban Households**

	(1)	(2)	(3)	(4)	(5)
	IHDS	SECC	Difference	Coefficient	Delta
Air Conditioning	0.04	0.08	0.04	17828.13	730.55
Computer	0.13	0.14	0.01	35374.57	467.70
Indoor Toilet	0.67	0.79	0.12	4480.83	536.28
Home Ownership	0.84	0.77	-0.07	-18463.89	1292.87
Separated Kitchen	0.71	0.72	0.01	-1263.06	-7.83
Number of Rooms in Home	2.76	2.57	-0.19	5521.36	-1023.18
Both Mobile and Landline	0.11	0.07	-0.04	36283.40	-1536.97
Landline Phone	0.01	0.01	0.00	15472.10	65.36
Mobile Phone	0.80	0.80	-0.00	30299.29	-25.29
Refrigerator	0.46	0.46	0.00	24373.27	25.07
Brick Roof	0.02	0.07	0.05	-8017.59	-431.84
Concrete Roof	0.30	0.54	0.24	-2265.95	-548.96
GI Roof	0.11	0.14	0.03	-7757.90	-236.80
Grass Roof	0.06	0.04	-0.02	-10617.89	190.07
Plastic Roof	0.00	0.01	0.01	-4361.75	-46.38
Slate Roof	0.05	0.03	-0.02	-11647.66	262.99
Stone Roof	0.06	0.05	-0.01	1254.12	-8.92
Tile Roof	0.07	0.10	0.03	-8433.79	-257.29
Four Wheeled Vehicle	0.07	0.07	0.00	67723.48	234.79
Two Wheeled Vehicle	0.37	0.34	-0.03	35865.61	-1229.43
Brick Walls	0.31	0.66	0.35	19883.44	6933.78
Concrete Walls	0.52	0.13	-0.39	22303.87	-8708.71
GI Walls	0.02	0.01	-0.01	26696.24	-210.47
Grass Walls	0.01	0.03	0.02	7766.15	170.95
Mud Walls	0.07	0.08	0.01	15930.44	179.87
Plastic Walls	0.00	0.00	0.00	35704.37	68.23
Stone Walls	0.06	0.07	0.01	13754.52	98.40
Wooden Walls	0.01	0.01	-0.00	6778.21	-24.84
Washing Machine	0.16	0.22	0.06	19436.70	1156.77

*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.

*Note:* Table S4 presents a comparison of IHDS and SECC covariates that were used to generate per capita consumption small area estimates in the urban SHRUG. The IHDS and SECC columns indicate the value for each covariate in the SECC and IHDS surveys taken at the village level; because the SECC is a census, no weights were required, while the IHDS required the use of sampling weights. Column 3 presents the difference between the two. Column 4 shows the coefficient for each covariate when regressing per capita consumption on the set of covariates in the IHDS. Column 5 multiplies column 4 by column 3, representing the expected difference in per capita consumption between IHDS and SHRUG that is explained by that covariate. The omitted category for roof and wall materials was "other."

**Table S5**  
Cross-Sectional Partial Correlations of Night Lights

	District	Subdistrict	Village	Village
	(1)	(2)	(3)	(4)
Log Population	0.236*** (0.052)	1.257*** (0.034)	0.431*** (0.003)	0.406*** (0.003)
Log Non-Farm Employment	0.104* (0.058)	1.740*** (0.049)	0.705*** (0.005)	0.693*** (0.005)
Log Hours Electricity	0.130 (0.083)	0.553*** (0.031)	0.262*** (0.003)	0.213*** (0.004)
Log Consumption	0.053** (0.026)	0.083*** (0.008)	0.097*** (0.001)	0.080*** (0.001)
N	632	5756	425049	424855
Fixed Effects	None	None	District	Subdistrict

\* $p < 0.10$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$

*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.

*Note:* Table S5 shows the partial correlation between rural luminosity and population, employment, electricity, and consumption. Each estimate is from a separate cross-sectional regression of Equation 1, with added controls for all the other variables in the table. Each entry also controls the number of 1km x 1km cells in the geographic unit. Column 1 aggregates data to the district level, Column 2 to the subdistrict level, and Columns 3 and 4 to the village level. Columns 2-4 are clustered at the district level. The table is comparable to Table 3, but is rural only and has additional controls for the other outcome variables in the table.

**Table S6**  
Time Series Correlates of Night Lights: Robustness Checks

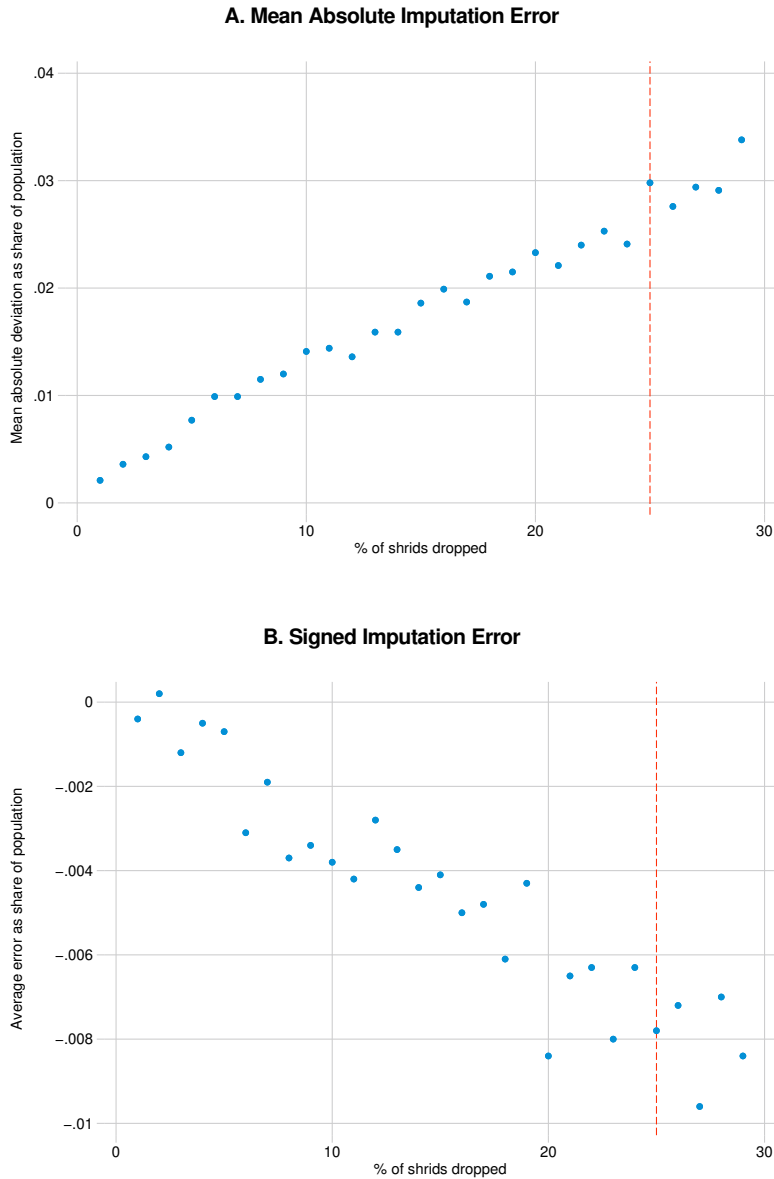
	<u>2001–2013</u>		<u>Pop-weighted</u>	
	(1)	(2)	(3)	(4)
Log Population	0.006*** (0.001)	0.004*** (0.001)	0.005*** (0.001)	0.003*** (0.001)
Log Non-Farm Employment	0.024*** (0.008)	0.024*** (0.005)	0.024*** (0.003)	0.025*** (0.003)
Log Manufacturing Employment	-0.016 (0.010)	-0.006 (0.006)	0.007 (0.004)	0.008** (0.004)
Log Services Employment	0.030*** (0.006)	0.027*** (0.004)	0.024*** (0.003)	0.025*** (0.002)
Electricity	0.083*** (0.012)	0.070*** (0.009)	0.045*** (0.004)	0.038*** (0.003)
N	1045252	1044904	1901229	1900543
Geographic Aggregation	Village	Village	Village	Village
Fixed Effects	Village, District * Year	Village, Subdistrict * Year	Village, District * Year	Village, Subdistrict * Year

\* $p < 0.10$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$

*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.  
*Note:* Table S6 shows the time series relationship between a set of rural development outcomes and night-time luminosity at the village level. Columns 1 and 2 restrict the data sample to 2001–2013. Columns 3 and 4 weight regressions by village population. Otherwise, estimates are similar to Columns 3 and 4 in Table 4. All variables are measured in logs. All regressions include village fixed effects and are clustered at the district level.

# Figure S1

## Error Rates from Imputation Simulation



*Source:* Authors' analysis based on data in the Socioeconomic High-resolution Rural-Urban Geographic Dataset on India.

*Note:* Panel A of Figure S1 shows the mean absolute deviation of simulated estimates of constituency population as compared with actual constituency population, under scenarios where we set a different share of the population to missing. We run a simulation where before calculating constituency population, we drop village and town observations representing X% of constituency population, and then use our imputation methodology. The graph shows, for instance, that when we drop 20% of the data before imputation, our average constituency has a total population error of approximately 1.8%. Panel B shows the signed error rather than the absolute error, indicating a very small downward bias in population estimation from our method.