Report on Voting in the City of Pittsburgh

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1 Introduction

This report provides estimates of the voting behavior of different racial groups in the City of Pittsburgh. The actual voting decisions by racial group are unknown in many elections, and thus scholars use a variety of statistical models to estimate the support for each candidate by each racial group. The data commonly used to do so are the reported results at the precinct level and the corresponding distribution of racial groups in each precinct. All methods rely on assumptions to generate the estimates, and there is extensive discussion elsewhere of the relative merits of different methods (e.g., Greiner 2007; Barreto et al. 2022).

In this report, I focus on the following key questions. First, what is the estimated support by African Americans for candidates for election, and how does this compare to support by non-African American or White voters? Second, do African American, White, or non-African American voters in District 6 appear to vote differently than their counterparts outside of District 6?

The analysis considers a large number of elections from 2012 to 2021, including both general elections and Democratic primary elections. The exact set of elections considered is outlined in Appendix A and were provided to me by the RAC, after removing candidates with sufficiently small support in a manner determined by the RAC. Due to the large number of elections considered, the main report focuses on reporting aggregate patterns or trends across these elections. A table reporting the estimated support for each racial group used in the primary analysis (African American and non-African American) and each candidate is reported in Section 5.

2 Methodology

The methodology in this report follows the instructions from the RAC in the accompanying Scope of Work. The main report is structured as follows.

I first focus on the analysis of two racial groups (African American and non-African American) and report two methods for estimating the vote choice of members of each group. First, I use Ecological Inference (EI). The methodology is somewhat complex, but is described extensively elsewhere (e.g., King 1997; Rosen et al. 2001), and Barreto et al. (2022) provide a recent overview. Many of the electoral races under consideration have multiple candidates and—in the secondary analysis—multiple racial groups being analyzed. In the main analysis, around 25% of the elections considered have more than two candidates. I thus rely on Rosen et al. (2001)'s "Multinomial-Dirichlet" version of Ecological Inference as this can handle multiple candidates (and multiple racial groups) without difficulty.[1] Alternative methods for running ecological inference (e.g. "iteratively" performing traditional ecological inference) are shown Appendix C and give similar results. Barreto

[1] This approach is a Bayesian method. Diagnostics for convergence are discussed in Appendix F.

et al. (2022) provides a discussion of the existing literature and debate around which method is preferable (see also Greiner 2007). All of the primary statistical analyses are conducted using the `eiCompare` package and required underlying packages in `R`.[2]

Second, the RAC asked for bivariate ecological regression (BER), also commonly known as "Goodman's regression". In the two racial group / two candidate case, this is relatively straightforward. It is less conventional in the multi-candidate and/or multiple racial group setting, although Collingwood et al. (2016) provide an implementation that I report in the main text.[3] Note that this method can relatively often result in estimates that are above 100% or below 0%; the software I employed rounds these to "100%" or "0%" (respectively). I report that number here, but I note that this estimate should be viewed more cautiously.

Broadly speaking, the two methods return highly similar answers; their individual predictions in the two-racial group case are correlated at 0.93, pooling across all city-wide analyses. Appendix B provides a visual comparison of the estimates from the two methods.

The RAC also requested an analysis that considers four racial groups (White, African American, Asian, Other) instead of two (African American, Non-African American). I present results using this methodology comparing White and African American voters in Appendix E; the results are similar to those in the main text.

The second major section of the report examines how voters in District 6 (on the existing 2012 boundaries) compare to voters in the remainder of the City. I do this by running the above analyses separately on (i) the precincts in District 6 and (ii) the precincts in the remainder of the City. This analysis does not consider elections where District 6 was not included (e.g. other city council districts, certain school director districts, certain state house districts, etc.). I use the same type of models discussed above for this analysis.

2.1 Miscellaneous Remarks

Please note that the following abbreviations are used for electoral contests. This dictionary was provided by the RAC with some modifications to shorten certain long names. The district number appears after the abbreviation; "AT-LG" indicates "at large". All other names are as provided from the RAC and are self-explanatory.

Table 1: Selected Abbreviations for Electoral Contests

Abbreviation	Name
CD	Pittsburgh City Council District
PPS	Pittsburgh School Director District
HD	Pennsylvania State House District
PA ATTY GEN	Pennsylvania Attorney General
PA AUDITOR GEN	Pennsylvania Auditor General
DISTRICT ATTY	Allegheny County District Attorney
COUNTY EXEC	Allegheny County Executive

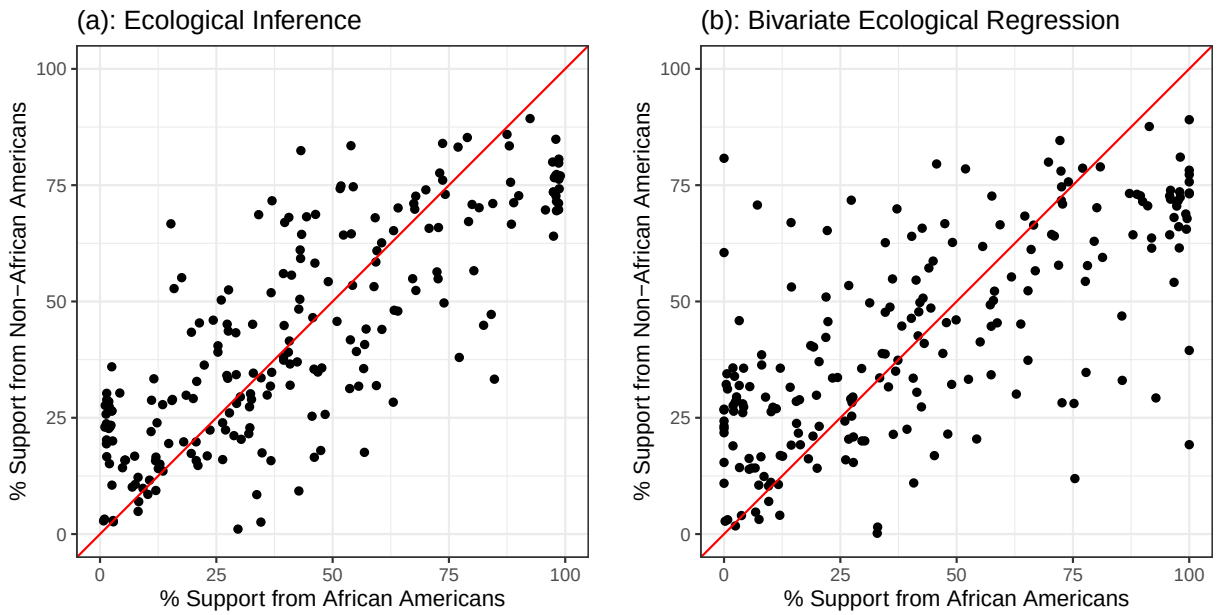
[2]This depends on the `eiPack` (Lau, Moore and Kellerman, 2007) and `ei` software that implements the methods in King (1997). More information can be found in Appendix A.

[3]Appendix D compares a different implementation of BER from `eiPack`. The results are similar.

3 City-Wide Results

Figure 1 shows the correlation between the support for each candidate by African American voters (horizontal axis) and Non-African American voters (vertical axis). We see that, broadly speaking, the estimates are highly correlated; the correlation is 0.79 for Ecological Inference (EI; Panel [a] in Figure 1) and 0.69 for Bivariate Ecological Regression (BER); Panel [b]).

Figure 1: Support for Candidates by Racial Group



Note: Each figure plots the estimated percent support for a candidate from each racial group across the elections considered. The 45-degree line is indicated in red. The left panel shows results using ecological inference [EI] and the right panel shows results using Bivariate Ecological Regression [BER].

Next, I examine whether African Americans and Non-African Americans are estimated to have the same most-supported candidate. For example, consider the estimates from the 2020 presidential election (general and Democratic primary). Table 2 shows the results of the statistical analysis for this election. It reports that, using Ecological Inference (EI), that 88% of African Americans are estimated to support Biden (vs. 12% for Sanders). While the numbers are not identical between BER and EI, they tell a similar story across both elections: African American voters are estimated to have supported Biden at a very high rate (90%+) in the general election and considerably more than Sanders in the primary.

The analysis also suggests that White voters, *in the City of Pittsburgh*, are estimated to still have supported Biden by a considerable margin in the general election (74% with EI; 64% with BER), although a more substantial number supported Trump (26 or 36%, respectively). In both the primary and the general election, both African Americans and White voters are estimated to have the same most-supported candidate (Biden in the primary; Biden in the general election).

Table 2: Example Results from EI and BER

Election	Type	Candidate	EI		BER	
			AfAm.	Non-AfAm.	AfAm.	Non-AfAm.

2020 PRESIDENT	G	BIDEN	97.45	73.53	95.80	64.34
		TRUMP	2.55	26.47	4.20	35.66
2020 PRESIDENT	P	BIDEN	88.43	66.62	87.91	64.33
		SANDERS	11.57	33.38	12.09	35.67

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

To summarize the cases where both racial groups have the same most-supported candidate, Table 3 reports the percentage of races where African Americans and Non-African Americans have the same candidate who is estimated to receive the most support ("most-supported candidate").

Table 3: Percentage of Elections Where Racial Groups Have Same Most-Supported Candidate

Election Type	Num. of Elect.	% Agree (EI)	% Agree (BER)
GENERAL	32	93.8	90.6
PRIMARY	60	68.3	70.0

Note: This table reports the percentage of contests where both African Americans and non-African Americans have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support from the group. "Num. of Elect." notes the number of elections considered. The "% Agree" column denotes the percent of those elections where the racial groups agree.

It shows that in the overwhelming majority of general elections (around 90%), both groups are estimated to have the same most-supported candidate. In primary elections, the figure is lower although still relatively high (around 70%). Ecological Inference and Bivariate Ecological Regression return very similar results.

Table 4 breaks apart this analysis by the year of the election. It should be noted that some years have relatively few electoral contests (as indicated in the number of elections column). It suggests a relatively consistent pattern across time, although the 2021 primary shows more disagreement than previous years.

Table 4: Most-Supported Candidate Agreement by Year

Election Type	Year	Num. of Elect.	% Agree (EI)	% Agree (BER)
GENERAL	2012	1	100.0	100.0
	2013	1	100.0	100.0
	2014	2	100.0	100.0
	2015	2	100.0	100.0
	2016	6	100.0	100.0
	2017	1	100.0	100.0
	2018	2	100.0	100.0
	2019	7	85.7	71.4
	2020	6	100.0	100.0
	2021	4	75.0	75.0
PRIMARY	2012	2	100.0	100.0
	2013	2	100.0	50.0
	2014	5	100.0	60.0
	2015	7	71.4	85.7
	2016	4	75.0	75.0
	2017	8	75.0	62.5
	2018	6	66.7	100.0
	2019	10	70.0	60.0
	2020	7	57.1	85.7
	2021	9	33.3	44.4

Note: This table reports the percentage of contests where both African Americans and non-African Americans have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support from the group. "Num. of Elect." notes the number of elections considered. The "% Agree" column denotes the percent of those elections where the racial groups agree. The table lists general elections first and then primary elections.

To examine the cases of *disagreement* more fully, Table 5 reports the estimates of support by racial group and candidate for all of the elections where the groups are estimated to have different most-supported candidates. I include any election where either EI or BER suggest that the two groups differ on their most-supported candidate. Section 5 provides the corresponding estimates for all electoral contests.

Table 5: Estimates for Elections Where Most-Supported Differs

Election	Type	Candidate	EI		BER	
			AfAm.	Non-AfAm.	AfAm.	Non-AfAm.
2013 MAYOR	P	PEDUTO	41.16	55.66	35.67	48.79
		WAGNER	29.19	43.27	31.31	49.70
		WHEATLEY	29.65	1.07	33.02	1.51
2014 HD 20	P	MICHALOW	39.47	37.39	41.28	54.59
		RAVENSTAHL	60.53	62.61	58.72	45.41
2014 HD 36	P	MOLCHANY	45.73	46.53	0.00	80.78
		READSHAW	54.27	53.47	100.00	19.22
2015 CD 7	P	GROSS	44.40	68.21	42.59	65.76
		MAYES	55.60	31.79	57.41	34.24
2015 PPS 4	P	BURKLEY	56.83	17.57	48.10	21.50
		WRENN	43.17	82.43	51.90	78.50
2016 HD 19	P	WHEATLEY	84.77	33.30	85.60	33.04
		WOLFE	15.23	66.70	14.40	66.96
2017 CD 4	P	COGHILL	46.19	58.25	36.21	54.85
		DEEMER	53.81	41.75	63.79	45.15
2017 PPS 3	P	MYERS	45.99	35.46	55.06	41.31
		UDIN	54.01	64.54	44.94	58.69
2017 PPS 9	P	EDWARDS	84.09	47.22	92.83	29.27
		KLUG	15.91	52.78	7.17	70.73
2018 HD 19	P	ABNEY	39.57	44.84	34.63	38.71
		TAYLOR	5.32	15.91	7.93	16.61
		WHEATLEY	55.11	39.25	57.44	44.67
2018 HD 20	P	DEVINE	36.77	51.89	19.87	29.85
		RAVENSTAHL	63.23	48.11	80.13	70.15
2019 CD 1	G	ROSSELOT	19.64	43.39	14.49	53.12
		WILSON	80.36	56.61	85.51	46.88
2019 CD 1	P	BRENTLEY	34.58	2.58	32.93	0.18
		HARRIS	22.40	36.33	26.81	53.44
		WILSON	43.02	61.08	40.26	46.38
2019 CD 9	G	BURGESS	46.83	34.83	49.88	46.04
		TAYLOR	25.34	39.11	23.32	33.55
		WELCH	27.82	26.05	26.79	20.41
2019 DISTRICT ATTY	G	MIDDLEMAN	72.67	54.88	65.33	37.36
		ZAPPALA	27.33	45.12	34.67	62.64

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

Table 5: Estimates for Elections Where Most-Supported Differs

Election	Type	Candidate	EI		BER	
			AfAm.	Non-AfAm.	AfAm.	Non-AfAm.
2019 DISTRICT ATTY	P	JENKINS	82.45	44.88	77.82	34.75
		ZAPPALA	17.55	55.12	22.18	65.25
2019 PPS 4	P	BATISTA	50.94	45.73	42.77	50.72
		HARBIN	49.06	54.27	57.23	49.28
2019 PPS 6	P	FULTON	60.59	44.00	100.00	39.48
		GALLAGHER	39.41	56.00	0.00	60.52
2020 HD 19	P	ABNEY	26.06	50.31	18.64	40.53
		WHEATLEY	73.94	49.69	81.36	59.47
2020 HD 20	P	KINKEAD	40.59	68.08	42.10	49.78
		RAVENSTAHL	59.41	31.92	57.90	50.22
2020 HD 36	P	BENHAM	27.63	52.49	21.92	50.96
		JOHNSON	11.99	9.37	0.00	15.40
		KASS	36.74	15.78	75.41	11.93
		MOELLER	23.64	22.36	15.98	21.70
2021 CD 4	G	COGHILL	36.97	71.65	27.35	71.77
		MULVANEY	63.03	28.35	72.65	28.23
2021 CD 4	P	CAMERON	56.67	35.58	62.83	30.09
		COGHILL	43.33	64.42	37.17	69.91
2021 MAYOR	P	GAINEY	77.22	37.97	75.22	28.08
		MORENO	1.43	16.64	5.53	31.71
		PEDUTO	21.36	45.39	19.24	40.22
2021 PA SUPERIOR COURT	P	BECK	39.69	66.99	40.35	64.01
		LANE	47.44	17.97	45.22	16.87
		NEFT	12.87	15.04	14.44	19.12
2021 PPS 3	P	FRAZIER	56.89	40.75	52.54	33.27
		UDIN	43.11	59.25	47.46	66.73
2021 PPS 7	P	PIOTROWSKI	46.33	68.72	45.69	79.56
		SCANTLING	53.67	31.28	54.31	20.44
2021 PPS 9	P	EDWARDS	40.85	36.56	44.45	48.59
		WALKER	24.33	45.98	16.22	28.88
		WALTON	34.82	17.46	39.32	22.54

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

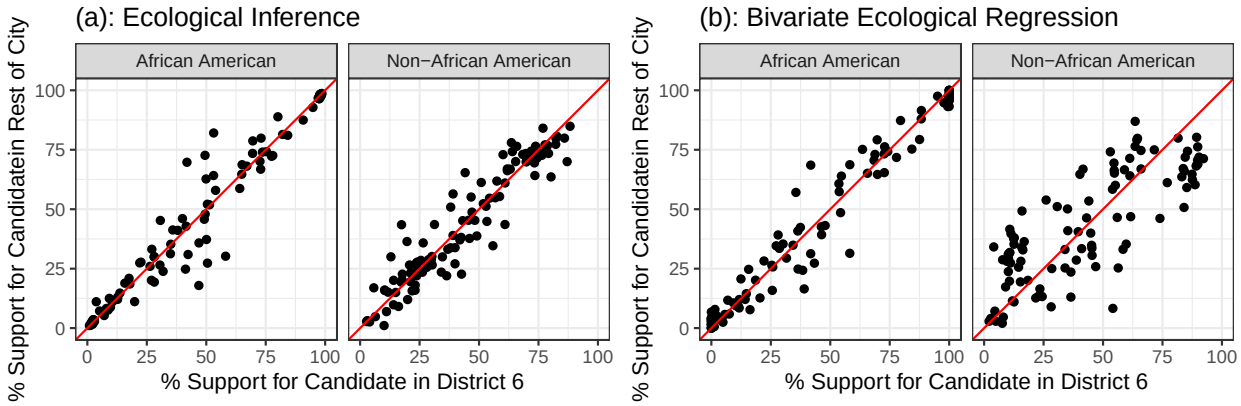
To interpret this table, consider the 2015 primary for Pittsburgh Schools Director (District 4) (2015 PPS 4 - P). It shows that African American votes are estimated to be relatively closely divided between Burkley and Wrenn (57-43 for EI; 48-52 for BER). By contrast, non-African American voters are estimated to have a strong preference for Wrenn (18-82 for EI; 21.5-78.5 for BER). Thus, while the methods disagree slightly in the most-supported candidate for African American voters

(EI says Burkley; BER says Wrenn), the overall story is broadly consistent across methods.[4]

4 District 6 Analysis

This section examines the behavior in District 6 vs. the rest of the City. I begin by showing the estimated support for each candidate (in each electoral contest) in District 6 and in the remainder of the City.[5] I show the results for African Americans and non-African Americans separately. The figure shows a strong relationship between the estimates inside of District 6 and for the remainder of the City. For EI, the correlation between the District 6 estimates and the non-District 6 estimates is very high (0.98 for African Americans; 0.94 for non-African Americans). For BER, the correlation for African American voters is very high (0.98), although somewhat lower for non-African American voters (0.79).

Figure 2: Comparing District 6 Against Remainder of City



Note: Each figure plots the estimated percent support for a candidate from District 6 versus the remainder of the City. Each panel shows, respectively, African American and non-African American voters. The 45-degree line is indicated in red. The left figure shows results using Ecological Inference [EI] and the right figures shows results using Bivariate Ecological Regression [BER].

In a similar spirit to the most-supported candidate for each racial group (see Table 3 above), I calculate the most-supported candidate for each racial group in District 6 and outside of District 6 in each electoral contest. Table 6 reports the percentage of times that racial groups inside and outside of District 6 share the same most-supported candidate. The difference in the number of elections comes from the fact that the BER procedure cannot estimate the District 6 results for the 2017 and 2021 PPS (District 5) elections as only one precinct of District 6 is included in that

[4] A systematic comparison of the estimates between EI and BER is shown in Appendix B; overall, the predictions across all racial groups and electoral contests are highly correlated (0.93).

[5] This relies on a smaller set of elections where there are precincts for both District 6 and not District 6 included. For example, certain school director districts are excluded from the analysis as it contains no precincts in District 6.

district.[6]

To help interpret this table, it says that in *primary elections*, the African American voters inside of District 6 are estimated to share the same most-supported candidate with African American voters *outside* of District 6 in around 85% of elections (84.6 for EI; 87.5 for BER).

Table 6: Most-Supported Candidate Agreement between District 6 and City

Election Type	Racial Group	EI		BER	
		Num. of Elect.	% Agree	Num. of Elect.	% Agree
GENERAL	African American	21	100.0	20	100.0
GENERAL	Non-African American	21	100.0	20	95.0
PRIMARY	African American	26	84.6	24	87.5
PRIMARY	Non-African American	26	80.8	24	75.0

Note: This table reports the percentage of contests where voters in District 6 and outside of District 6 have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support. "Racial Group" reports the racial group under consideration. For both Ecological Inference (EI) and Bivariate Ecological Regression (BER), "Num. of Elect." notes the number of elections considered and "% Agree" notes the percent of elections where the District 6 and non-District 6 voters have the same most-supported candidate.

Overall, these figures are also high across both general and primary elections, regardless of the method (EI or BER) employed. As above, Table 7 presents the cases where District 6 voters disagree with those outside of District 6. For completeness, it includes all results for an election where *either* racial group disagrees between District 6 and the remainder of the City.

For example, consider the 2013 mayoral primary. Ecological Inference suggests that African Americans disagreed on their most-supported candidate; those inside of District 6 are estimated to have supported Wheatley the most, while those outside of District 6 are estimated to have supported Peduto the most. For non-African American voters, however, District 6 and the remainder of the City agree—Peduto is the most-supported candidate. Bivariate Ecological Regression reports a slightly different story; it suggests that non-African American voters outside of District 6 most support Wagner (not Peduto).

[6]This excludes the 2017 primary, the 2021 primary, and the 2021 general election from the BER analysis.

Table 7: Elections Where District 6 Differs from Rest of City

Election	Type	Race	Candidate	EI		BER	
				Not-D6	D6	Not-D6	D6
2013 MAYOR	P	AfAm.	PEDUTO	45.27	30.68	39.17	28.08
			WAGNER	29.93	28.05	33.52	28.59
			WHEATLEY	24.80	41.27	27.31	43.33
2013 MAYOR	P	Non-AfAm.	PEDUTO	55.35	58.65	46.86	61.63
			WAGNER	43.56	31.27	51.10	30.74
			WHEATLEY	1.08	10.08	2.04	7.63
2015 PPS 8	P	AfAm.	CARTER	46.06	39.99	57.07	35.54
			MORIARTY	30.06	28.16	26.44	25.42
			ROGERS	23.88	31.85	16.50	39.03
2015 PPS 8	P	Non-AfAm.	CARTER	33.83	39.94	50.12	35.07
			MORIARTY	22.70	42.64	8.31	54.14
			ROGERS	43.48	17.41	41.57	10.80
2017 PPS 3	P	AfAm.	MYERS	30.25	58.13	31.45	58.21
			UDIN	69.75	41.87	68.55	41.79
2017 PPS 3	P	Non-AfAm.	MYERS	38.16	42.49	33.65	45.32
			UDIN	61.84	57.51	66.35	54.68
2017 PPS 5	P	AfAm.	KENNEDY	62.73	49.91	72.63	NA
			MAKOSHI	37.27	50.09	27.37	NA
2017 PPS 5	P	Non-AfAm.	KENNEDY	65.37	44.16	73.81	NA
			MAKOSHI	34.63	55.84	26.19	NA
2018 HD 19	P	AfAm.	ABNEY	30.96	42.35	24.33	38.40
			TAYLOR	11.10	3.74	11.73	6.91
			WHEATLEY	57.94	53.91	63.94	54.69
2018 HD 19	P	Non-AfAm.	ABNEY	50.89	38.08	40.97	35.20
			TAYLOR	12.02	19.98	12.68	21.72
			WHEATLEY	37.09	41.94	46.35	43.09
2019 COUNTY COUNCIL 13	P	AfAm.	BENNETT	68.72	65.06	68.72	58.23
			RUSSELL	31.28	34.94	31.28	41.77
2019 COUNTY COUNCIL 13	P	Non-AfAm.	BENNETT	54.64	54.41	53.46	44.03
			RUSSELL	45.36	45.59	46.54	55.97
2019 COUNTY COUNCIL AT-LG	P	AfAm.	DEFAZIO	47.91	49.53	60.72	53.64
			HALLAM	52.09	50.47	39.28	46.36
2019 COUNTY COUNCIL AT-LG	P	Non-AfAm.	DEFAZIO	35.84	26.52	53.86	26.07
			HALLAM	64.16	73.48	46.14	73.93
2019 DISTRICT ATTY	G	AfAm.	MIDDLEMAN	73.47	69.48	64.63	69.85
			ZAPPALA	26.53	30.52	35.37	30.15
2019 DISTRICT ATTY	G	Non-AfAm.	MIDDLEMAN	54.81	56.85	35.33	59.73
			ZAPPALA	45.19	43.15	64.67	40.27
2019 DISTRICT ATTY	P	AfAm.	JENKINS	81.44	82.11	75.28	84.32
			ZAPPALA	18.56	17.89	24.72	15.68
2019 DISTRICT ATTY	P	Non-AfAm.	JENKINS	44.88	53.32	33.14	58.41
			ZAPPALA	55.12	46.68	66.86	41.59

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. Race indicates the racial group whose electoral results are shown on that row. "AfAm." stands for African American. "Non-AfAm." stands for non-African American. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression. "D6" stands for District 6; "Not-D6" stands for the remainder of the City.

Table 7: Elections Where District 6 Differs from Rest of City

Election	Type	Race	Candidate	EI		BER	
				Not-D6	D6	Not-D6	D6
2021 MAYOR	P	AfAm.	GAINEY	78.73	69.57	76.26	72.87
			MORENO	1.91	2.28	7.86	1.51
			PEDUTO	19.36	28.15	15.87	25.63
2021 MAYOR	P	Non-AfAm.	GAINEY	37.72	46.00	25.30	56.38
			MORENO	16.95	5.76	34.14	4.05
			PEDUTO	45.32	48.24	40.55	39.57
2021 PPS 5	P	AfAm.	KENNEDY	27.33	50.52	22.79	NA
			REED	72.67	49.48	77.21	NA
2021 PPS 5	P	Non-AfAm.	KENNEDY	43.57	60.91	43.16	NA
			REED	56.43	39.09	56.84	NA

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. Race indicates the racial group whose electoral results are shown on that row. "AfAm." stands for African American. "Non-AfAm." stands for non-African American. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression. "D6" stands for District 6; "Not-D6" stands for the remainder of the City.

5 Results For Each Election

This section lists the estimated support by each racial group for each candidate and contest. Table 8 lists the ninety-two city-wide elections analyzed.

Table 8: Estimates for All Elections (City-Wide)

Election	Type	Candidate	EI		BER	
			AfAm	Non-AfAm.	AfAm	Non-AfAm.
2012 HD 24	P	GAINEY	29.27	34.27	29.58	35.59
		PRESTON	70.73	65.73	70.42	64.41
2012 US HOUSE 14	G	DOYLE	98.95	77.01	100.00	77.27
		LESSMANN	1.05	22.99	0.00	22.73
2012 US HOUSE 14	P	BROOKS	26.36	16.02	30.25	20.03
		DOYLE	73.64	83.98	69.75	79.97
2013 CD 6	P	HARRIS	13.46	27.83	15.53	28.52
		LAVELLE	57.19	44.08	41.44	30.49
		PAYNE	29.35	28.09	43.03	40.99
2013 MAYOR	P	PEDUTO	41.16	55.66	35.67	48.79
		WAGNER	29.19	43.27	31.31	49.70
		WHEATLEY	29.65	1.07	33.02	1.51
2013 MAYOR	G	PEDUTO	97.98	84.87	98.08	81.04
		WANDER	2.02	15.13	1.92	18.96
2014 GOVERNOR	P	McCORD	11.93	15.76	12.08	16.90
		McGINTY	9.22	9.83	10.06	11.12
		SCHWARTZ	10.97	22.04	5.95	14.19
		WOLF	67.89	52.37	71.91	57.79
2014 GOVERNOR	G	CORBETT	1.88	28.49	0.74	31.19
		WOLF	98.12	71.51	99.26	68.81
2014 HD 20	P	MICHALOW	39.47	37.39	41.28	54.59
		RAVENSTAHL	60.53	62.61	58.72	45.41
2014 HD 20	G	FODI	20.03	29.14	4.02	28.01
		RAVENSTAHL	79.97	70.86	95.98	71.99
2014 HD 24	P	ANDERSON	7.56	10.68	8.59	12.38
		GAINEY	92.44	89.32	91.41	87.62
2014 HD 27	P	DEASY	87.98	83.45	100.00	78.22
		RICHARDSON	12.02	16.55	0.00	21.78
2014 HD 36	P	MOLCHANY	45.73	46.53	0.00	80.78
		READSHAW	54.27	53.47	100.00	19.22
2015 CD 1	P	HARRIS	42.72	48.36	55.60	61.83
		WILSON	36.63	31.81	36.88	35.02
		ZOTTER	20.65	19.83	7.52	3.15
2015 CD 1	G	HARRIS	84.43	71.06	91.91	63.65
		SCHUILENBERG	15.57	28.94	8.09	36.35
2015 CD 5	P	KAPLAN	21.05	14.75	19.12	21.06
		O'CONNOR	78.95	85.25	80.88	78.94

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

Table 8: Estimates for All Elections (City-Wide)

Election	Type	Candidate	EI		BER	
			AfAm	Non-AfAm.	AfAm	Non-AfAm.
2015 CD 7	P	GROSS	44.40	68.21	42.59	65.76
		MAYES	55.60	31.79	57.41	34.24
2015 CD 9	P	BURGESS	42.95	50.48	44.03	57.20
		CARLISLE	10.28	8.53	11.69	10.66
		GINYARD	17.98	19.83	18.13	16.18
		YOUNG	28.79	21.16	26.15	15.97
2015 PPS 4	P	BURKLEY	56.83	17.57	48.10	21.50
		WRENN	43.17	82.43	51.90	78.50
2015 PPS 6	P	HURST	33.69	8.48	5.40	13.93
		KALEIDA	34.10	68.66	66.90	56.60
		LINK	32.21	22.86	27.70	29.47
2015 PPS 8	P	CARTER	42.39	37.01	47.80	45.46
		MORIARTY	30.16	29.50	27.81	20.89
		ROGERS	27.45	33.49	24.39	33.66
2015 PPS 8	G	CARTER	95.75	69.68	95.98	73.90
		MORIARTY	4.25	30.32	4.02	26.10
2016 HD 19	P	WHEATLEY	84.77	33.30	85.60	33.04
		WOLFE	15.23	66.70	14.40	66.96
2016 HD 20	G	BARR	12.52	14.08	0.00	10.92
		RAVENSTAHL	87.48	85.92	100.00	89.08
2016 HD 24	P	ANDERSON	6.92	10.11	7.47	10.52
		GAINEY	88.25	75.63	87.15	73.22
		KOGER	4.83	14.26	5.38	16.25
2016 PA ATTY GEN	P	SHAPIRO	35.93	29.89	27.80	15.39
		ZAPPALA	64.07	70.11	72.20	84.61
2016 PA ATTY GEN	G	RAFFERTY	1.44	28.88	0.47	32.17
		SHAPIRO	98.56	71.12	99.53	67.83
2016 PA AUDITOR GEN	G	BROWN	1.36	23.72	0.00	24.29
		DePASQUALE	98.64	76.28	100.00	75.71
2016 PRESIDENT	G	CLINTON	98.12	69.51	97.86	61.51
		JOHNSON	0.76	2.84	0.23	2.77
		TRUMP	1.12	27.65	1.91	35.72
2016 STATE TREASURER	G	TORSELLA	98.70	74.22	100.00	73.32
		VOIT	1.30	25.78	0.00	26.68
2016 US HOUSE	P	BROOKS	26.35	23.92	25.97	24.29
		DOYLE	73.65	76.08	74.03	75.71
2016 US SENATE	G	MCGINTY	98.57	69.74	99.39	65.54
		TOOMEY	1.43	30.26	0.61	34.46
2017 CD 4	G	CIBRONE-ABATE	46.06	16.51	0.00	26.85
		COGHILL	53.94	83.49	100.00	73.15
2017 CD 4	P	COGHILL	46.19	58.25	36.21	54.85
		DEEMER	53.81	41.75	63.79	45.15

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

Table 8: Estimates for All Elections (City-Wide)

Election	Type	Candidate	EI		BER	
			AfAm	Non-AfAm.	AfAm	Non-AfAm.
2017 COUNTY COUNCIL 12	P	ELLENBOGEN	32.56	28.95	34.00	38.81
		PALMOSINA	67.44	71.05	66.00	61.19
2017 MAYOR	P	HARRIS	5.47	15.89	10.12	26.32
		PEDUTO	51.80	74.84	49.10	62.70
		WELCH	42.74	9.27	40.78	10.99
2017 PPS 3	P	MYERS	45.99	35.46	55.06	41.31
		UDIN	54.01	64.54	44.94	58.69
2017 PPS 5	P	KENNEDY	63.10	65.23	72.77	70.95
		MAKOSHI	36.90	34.77	27.23	29.05
2017 PPS 7	P	BURNS	45.57	25.34	42.43	27.34
		FALLS	54.43	74.66	57.57	72.66
2017 PPS 9	P	EDWARDS	84.09	47.22	92.83	29.27
		KLUG	15.91	52.78	7.17	70.73
2017 SHERIFF	P	MULLEN	67.87	72.64	66.55	66.42
		SATLER	32.13	27.36	33.45	33.58
2018 GOVERNOR	G	WAGNER	1.38	19.40	2.07	26.41
		WOLF	98.62	80.60	97.93	73.59
2018 HD 19	P	ABNEY	39.57	44.84	34.63	38.71
		TAYLOR	5.32	15.91	7.93	16.61
		WHEATLEY	55.11	39.25	57.44	44.67
2018 HD 20	P	DEVINE	36.77	51.89	19.87	29.85
		RAVENSTAHL	63.23	48.11	80.13	70.15
2018 HD 24	P	ANDERSON	7.44	16.75	6.68	14.21
		GAINEY	90.00	72.74	89.99	71.49
		KOGER	2.56	10.52	3.32	14.30
2018 LT GOV	P	AHMAD	14.76	19.47	9.57	10.33
		COZZONE	8.18	4.87	9.61	7.02
		FETTERMAN	74.20	73.03	77.08	78.66
		STACK	2.86	2.63	3.74	3.98
2018 STATE SENATE 38	P	WALSH	51.61	74.27	40.66	33.51
		WILLIAMS	48.39	25.73	59.34	66.49
2018 US HOUSE 18	P	BROOKS	26.98	22.38	27.44	25.35
		DOYLE	73.02	77.62	72.56	74.65
2018 US SENATE	G	BARLETTA	1.40	20.25	1.95	27.61
		CASEY	98.60	79.75	98.05	72.39
2019 CD 1	G	ROSSELOT	19.64	43.39	14.49	53.12
		WILSON	80.36	56.61	85.51	46.88
2019 CD 1	P	BRENTLEY	34.58	2.58	32.93	0.18
		HARRIS	22.40	36.33	26.81	53.44
		WILSON	43.02	61.08	40.26	46.38
2019 CD 3	G	KRAUS	79.22	67.18	78.12	57.72
		NIXON	20.78	32.82	21.88	42.28

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

Table 8: Estimates for All Elections (City-Wide)

Election	Type	Candidate	EI		BER	
			AfAm	Non-AfAm.	AfAm	Non-AfAm.
2019 CD 3	P	KRAUS	58.89	53.20	47.04	38.83
		KUMANCHIK	8.17	12.20	15.58	23.79
		WOLFE	32.95	34.60	37.38	37.37
2019 CD 7	P	GROSS	59.29	58.49	61.78	55.28
		KANE	40.71	41.51	38.22	44.72
2019 CD 9	G	BURGESS	46.83	34.83	49.88	46.04
		TAYLOR	25.34	39.11	23.32	33.55
		WELCH	27.82	26.05	26.79	20.41
2019 CD 9	P	BRAXTON	2.80	2.91	2.44	1.75
		BURGESS	39.45	38.04	41.71	42.61
		FULLER	12.25	23.92	14.21	31.56
		GINYARD	13.53	13.55	11.98	4.04
		YOUNG	31.97	21.58	29.65	20.03
2019 COUNTY CONTROLLER	G	NADONLEY	1.88	22.70	2.69	29.49
		WAGNER	98.12	77.30	97.31	70.51
2019 COUNTY COUNCIL 13	P	BENNETT	67.20	54.90	65.34	52.31
		RUSSELL	32.80	45.10	34.66	47.69
2019 COUNTY COUNCIL AT-LG	P	DEFAZIO	47.67	35.72	58.14	52.22
		HALLAM	52.33	64.28	41.86	47.78
2019 COUNTY EXEC	G	DROZD	2.71	20.02	4.21	27.31
		FITZGERALD	97.29	79.98	95.79	72.69
2019 DISTRICT ATTY	G	MIDDLEMAN	72.67	54.88	65.33	37.36
		ZAPPALA	27.33	45.12	34.67	62.64
2019 DISTRICT ATTY	P	JENKINS	82.45	44.88	77.82	34.75
		ZAPPALA	17.55	55.12	22.18	65.25
2019 PPS 2	G	RYS	23.04	16.81	11.23	26.96
		TALIAFERRO	76.96	83.19	88.77	73.04
2019 PPS 2	P	ATKINSON	30.34	20.37	36.38	21.45
		GRIFFIN-EL	19.60	17.33	20.45	23.17
		RYS	15.45	28.72	0.00	23.21
		TALIAFERRO	34.61	33.59	48.93	32.18
2019 PPS 4	P	BATISTA	50.94	45.73	42.77	50.72
		HARBIN	49.06	54.27	57.23	49.28
2019 PPS 6	P	FULTON	60.59	44.00	100.00	39.48
		GALLAGHER	39.41	56.00	0.00	60.52
2020 HD 19	P	ABNEY	26.06	50.31	18.64	40.53
		WHEATLEY	73.94	49.69	81.36	59.47
2020 HD 20	P	KINKEAD	40.59	68.08	42.10	49.78
		RAVENSTAHL	59.41	31.92	57.90	50.22
2020 HD 36	G	BENHAM	59.14	68.00	91.92	61.46
		DOYLE	40.86	32.00	8.08	38.54

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

Table 8: Estimates for All Elections (City-Wide)

Election	Type	Candidate	EI		BER	
			AfAm	Non-AfAm.	AfAm	Non-AfAm.
2020 HD 36	P	BENHAM	27.63	52.49	21.92	50.96
		JOHNSON	11.99	9.37	0.00	15.40
		KASS	36.74	15.78	75.41	11.93
		MOELLER	23.64	22.36	15.98	21.70
2020 PA ATTY GEN	G	HEIDELBAUGH	2.35	23.39	2.72	28.63
		SHAPIRO	97.65	76.61	97.28	71.37
2020 PA AUDITOR GEN	G	AHMAD	98.00	72.69	97.74	66.08
		DEFOOR	2.00	27.31	2.26	33.92
2020 PA AUDITOR GEN	P	AHMAD	20.68	15.80	20.01	14.16
		FOUNTAIN	8.32	6.98	6.78	4.72
		HARTMAN	0.96	3.22	0.78	3.09
		LAMB	70.04	74.00	72.43	78.03
2020 PA TREASURER	G	GARRITY	2.53	26.46	3.26	31.95
		TORSELLA	97.47	73.54	96.74	68.05
2020 PRESIDENT	G	BIDEN	97.45	73.53	95.80	64.34
		TRUMP	2.55	26.47	4.20	35.66
2020 PRESIDENT	P	BIDEN	88.43	66.62	87.91	64.33
		SANDERS	11.57	33.38	12.09	35.67
2020 STATE SENATE 43	P	BRITTAIN	11.07	28.77	8.92	29.44
		COSTA	88.93	71.23	91.08	70.56
2020 US HOUSE 18	G	DOYLE	97.87	76.97	97.61	71.65
		NEGRON	2.13	23.03	2.39	28.35
2020 US HOUSE 18	P	DICKINSON	40.48	39.10	35.34	31.64
		DOYLE	59.52	60.90	64.66	68.36
2021 CD 2	P	KAIL-SMITH	67.65	69.84	72.50	71.72
		WILLIAMSON	32.35	30.16	27.50	28.28
2021 CD 4	G	COGHILL	36.97	71.65	27.35	71.77
		MULVANEY	63.03	28.35	72.65	28.23
2021 CD 4	P	CAMERON	56.67	35.58	62.83	30.09
		COGHILL	43.33	64.42	37.17	69.91
2021 MAYOR	G	GAINEY	97.48	64.04	96.74	54.11
		MORENO	2.52	35.96	3.26	45.89
2021 MAYOR	P	GAINEY	77.22	37.97	75.22	28.08
		MORENO	1.43	16.64	5.53	31.71
		PEDUTO	21.36	45.39	19.24	40.22
2021 PA SUPERIOR COURT	P	BECK	39.69	66.99	40.35	64.01
		LANE	47.44	17.97	45.22	16.87
		NEFT	12.87	15.04	14.44	19.12
2021 PPS 1	P	HIGGINBOTHAM	25.35	40.48	16.41	19.20
		THOMAS	10.64	11.60	12.59	16.73
		WILSON	64.01	47.93	71.00	64.07

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

Table 8: Estimates for All Elections (City-Wide)

Election	Type	Candidate	EI		BER	
			AfAm	Non-AfAm.	AfAm	Non-AfAm.
2021 PPS 3	P	FRAZIER	56.89	40.75	52.54	33.27
		UDIN	43.11	59.25	47.46	66.73
2021 PPS 5	G	KENNEDY	18.51	29.85	10.51	27.27
		REED	81.49	70.15	89.49	72.73
2021 PPS 5	P	KENNEDY	27.57	43.64	22.33	45.67
		REED	72.43	56.36	77.67	54.33
2021 PPS 7	P	PIOTROWSKI	46.33	68.72	45.69	79.56
		SCANTLING	53.67	31.28	54.31	20.44
2021 PPS 9	G	EDWARDS	27.25	34.10	20.43	37.06
		WALKER	72.75	65.90	79.57	62.94
2021 PPS 9	P	EDWARDS	40.85	36.56	44.45	48.59
		WALKER	24.33	45.98	16.22	28.88
		WALTON	34.82	17.46	39.32	22.54

Note: "Election" indicates the name of the electoral contest. "Type" indicates general election ("G") or primary ("P"). Candidate is the surname of the candidate. "AfAm." stands for African American vote share. "Non-AfAm." stands for non-African American vote share. "EI" contains two columns reporting the results from the Ecological Inference procedure; "BER" contains two columns reporting the results from the Bivariate Ecological Regression.

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Appendix for Report on Voting in the City of Pittsburgh

The remainder of the document contains appendices with supplemental information. Appendix A outlines the statistical software used to estimate the models, as well as outlining certain data coding and cleaning rules. Appendix B compares the results of EI and BER in the two racial group case. Appendix C examines a different method for performing Ecological Inference. Appendix D compares a different method for performing Bivariate Ecological Regression. Appendix E examines the main analysis when four racial groups are considered. Appendix F provides diagnostics on the Bayesian Ecological Inference reported in the main text.

A Software and Data

A.1 Software

All analyses are conducted in `R`. The session information of the environment used is shown below.

```
> sessionInfo()
R version 4.0.2 (2020-06-22)
Platform: x86_64-w64-mingw32/x64 (64-bit)
Running under: Windows 10 x64 (build 19041)

Matrix products: default

locale:
[1] LC_COLLATE=English_United States.1252
[2] LC_CTYPE=English_United States.1252
[3] LC_MONETARY=English_United States.1252
[4] LC_NUMERIC=C
[5] LC_TIME=English_United States.1252

attached base packages:
[1] parallel  stats     graphics  grDevices utils     datasets  methods
[8] base

other attached packages:
[1] reshape2_1.4.4    coda_0.19-4       doParallel_1.0.17 iterators_1.0.14
[5] foreach_1.5.2     posterior_1.2.1   eiCompare_3.0.0   wru_0.1-12
[9] ei_1.3-3          eiPack_0.2-1      readxl_1.4.0      glue_1.6.2
[13] forcats_0.5.1     stringr_1.4.0     dplyr_1.0.9       purrr_0.3.4
[17] readr_2.1.2       tidyr_1.2.0       tibble_3.1.7      ggplot2_3.3.6
[21] tidyverse_1.3.1

loaded via a namespace (and not attached):
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[13] remotes_2.4.2        lubridate_1.8.0      fansi_1.0.3
```

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[37] tools_4.0.2           gtable_0.3.0          tinytex_0.38
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[82] generics_0.1.2        DBI_1.1.2             pillar_1.7.0
[85] haven_2.5.0           withr_2.5.0           units_0.8-0
[88] overlapping_1.7       abind_1.4-5           survival_3.1-12
[91] datawizard_0.4.1      sp_1.4-7              modelr_0.1.8
[94] crayon_1.5.1          KernSmooth_2.23-17    utf8_1.2.2
[97] ellipse_0.4.2         tmvnsim_1.0-2         tzdb_0.3.0
[100] usethis_2.1.5         grid_4.0.2            callr_3.7.0
[103] reprex_2.0.1          digest_0.6.29         classInt_0.4-3
[106] stats4_4.0.2          munsell_0.5.0         sessioninfo_1.2.2
```

A.2 Data

All data used in this analysis was provided by the RAC. The elections covered are listed in the Scope of Work—subject to modifications and exclusions made by the RAC when sending the final data. All electoral results are provided to me by the RAC and all elections provided in the final version of the data are analyzed here—subject to having a competitive election (discussed below).

Only minimal changes were made to the underlying data, and no changes were made to the precinct level returns provided. Following discussions with the RAC, the following procedure was used to remove candidates with limited support. If this procedure resulted in an election with only one remaining candidate (named or write-in), this election was excluded from the analysis.

- If there was one named candidate and one write-in candidate, exclude the write-in candidate if they obtain less than 10% of the total vote.
- If there were two named candidates (and possibly one write-in candidate), exclude all candidates (including the write-in) who obtained less than 10% of the total vote.

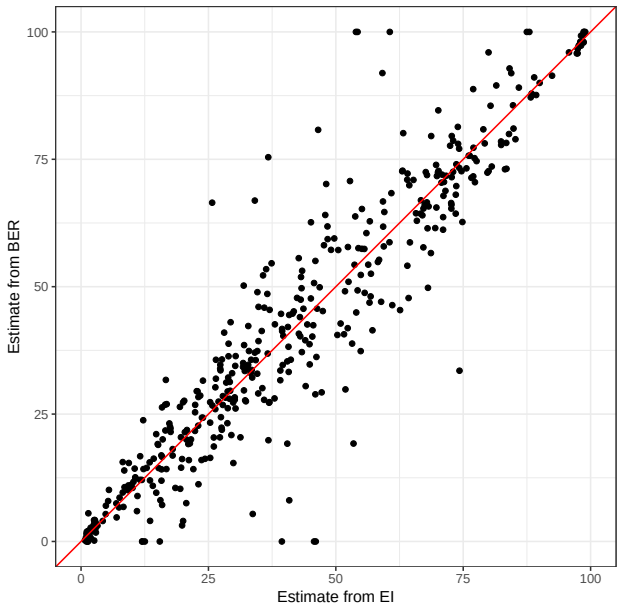
- If there were 3-4 named candidates (and possibly one write-in candidate), exclude all candidates (including the write-in) who obtained less than 5% of the total vote.
- If there were 5 or more named candidates (and possibly one write-in candidate), exclude all candidates (including the write-in) who obtained less than 2% of the total vote.

Given all remaining candidates (including a write-in if applicable), calculate their vote totals as percentage of all remaining candidates. In terms of census population data, if the election occurred between 2012 and 2019 (inclusive), I use the population data corresponding to the 2010 census adjusted for the consolidation of certain precincts as noted by the RAC in the provided data. If the election occurred in 2020 or 2021, I use the population data corresponding to the 2020 census.

B Comparing EI and BER

To systematically compare EI and BER, Figure 3 compares the point estimates for each method in the city-wide, two racial group, analysis used in the main text. As noted in the main text, the correlation between these predictions is high (0.93).

Figure 3: BER and EI



Note: This figure plots the estimates from EI and BER for each racial group and candidate across the elections considered. The 45-degree line is shown in red.

C Different Methods for Ecological Inference

The problem of how to address multiple racial groups for ecological inference, as well as multiple candidates, is more difficult than the traditional two candidates and two racial group setting. There are a variety of different solutions in this case; the main text presents the "Multinomial-Dirichlet" approach in Rosen et al. (2001) (see also Lau, Moore and Kellerman 2007). A common

alternative approach described in detail in Barreto et al. (2022) (see also King 1997) involves "iteratively" performing ecological inference on the traditional two racial group and two candidate setting. A detailed discussion can be found in Barreto et al. (2022) but it roughly proceeds as follows: For each racial group and candidate, collapse all other racial groups together and all other candidates together and perform standard ecological inference on the resulting two-by-two table. After repeating this for different combinations, the key quantities of interest can be uncovered. I use the implementation provided in Collingwood et al. (2016) and described in Barreto et al. (2022). Note that in the two racial group - two candidate setting, this recovers the original formulation of ecological inference proposed in King (1997).

Scholars disagree over which method is preferable in the multiple racial group and candidate setting (e.g., Greiner 2007; Barreto et al. 2022), although a recent analysis by Barreto et al. (2022) suggests that the methods often return relatively similar results. For completeness, I thus re-analyze the data using this "iterative" version of ecological inference and report the results below. There are two elections for which the iterative estimation process fails and a number where it cannot be estimated—as there is only one precinct.[7]

Figure 4 begins by replicating Figure 1. Panel (a) replicates the Panel (a) in Figure 1, and Panel (b) shows the alternative version of EI ("Ecological Inference: Iterative"). Visually, Figure 4 looks quite similar to the main analysis and the correlation between estimates for each racial group (African Americans and non-African Americans) is comparable (0.74) to the numbers reported in the main text (0.79 for EI [main text]; 0.69 for BER).

I next replicate the table from the main text (Table 3) on the most-supported candidate but now include two different versions of EI. The results are identical to the main version of EI.

Table 9: Percentage of Elections Where Racial Groups Have Same Most-Supported Candidate

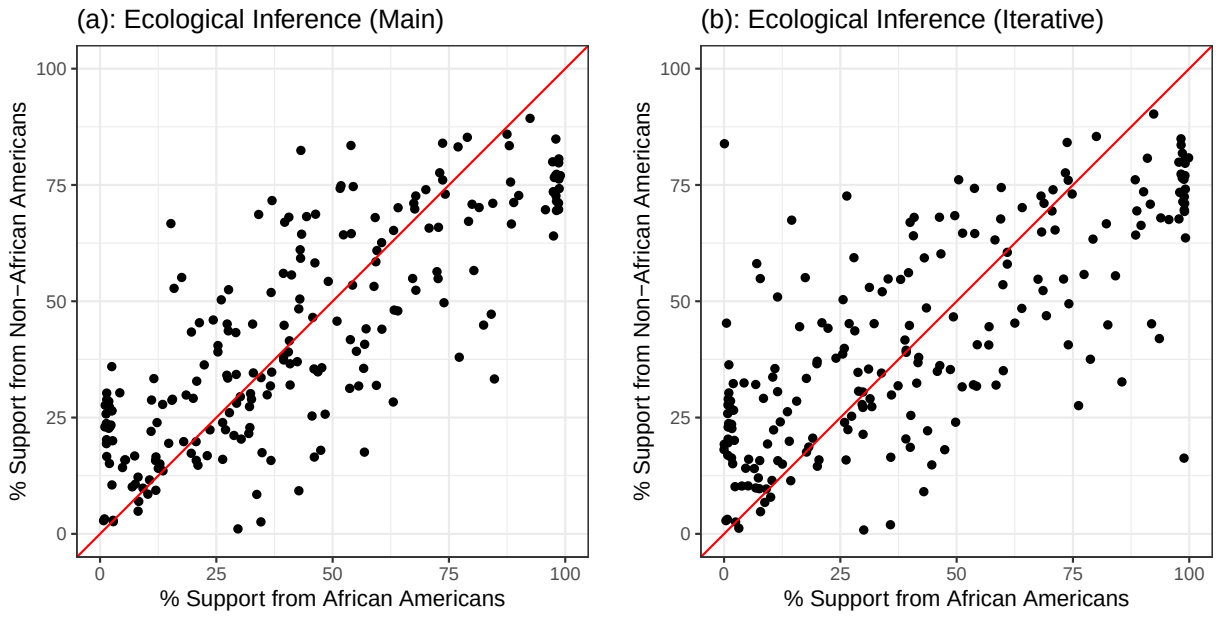
Election Type	Num. of Elect.	% Agree (EI)	% Agree (BER)	% Agree (EI-Iter)
GENERAL	32	93.8	90.6	93.8
PRIMARY	60	68.3	70.0	68.3

Note: This table reports the percentage of contests where both African Americans and non-African Americans have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support from the group. "Num. of Elect." notes the number of elections considered. The "% Agree" column denotes the percent of those elections where the racial groups agree. "EI-Iter" stands for the iterative version of Ecological Inference; "EI" refers to the version presented in the main text of the report.

The results for the District 6 analysis are similar between both versions of EI. The relationship between the estimates across the methods and racial groups is shown in Figure 5; they are very highly correlated.

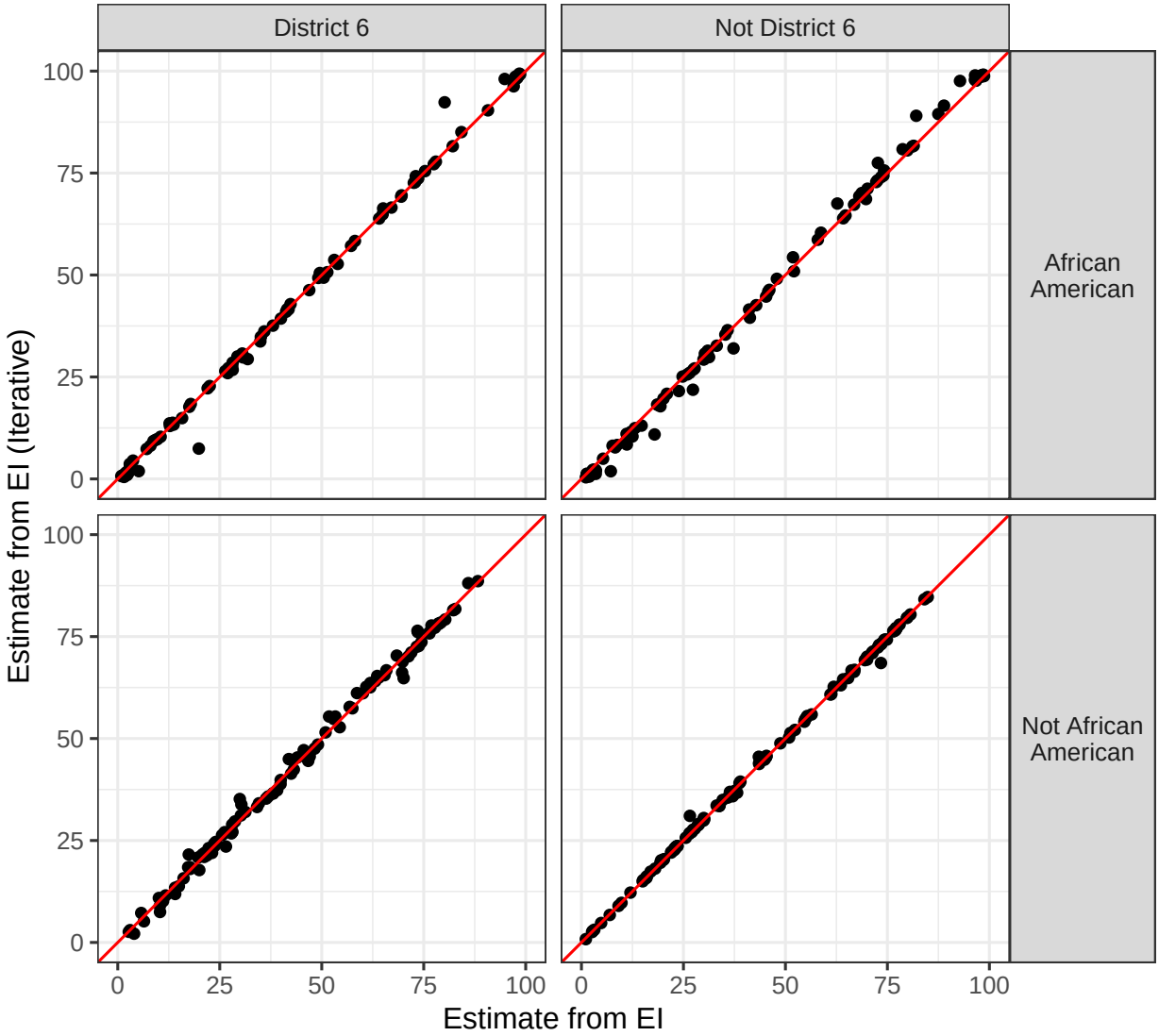
[7]The process fails for the four racial group analysis for the 2019 District Attorney primary (District 6 only) and the four racial group analysis for the 2021 City Council District 2 primary (city-wide analysis). Neither this iterative method nor BER can be estimated in cases where only one precinct exists, i.e. the 2017 and 2021 elections in the Pittsburgh Public School District 5, noted above.

Figure 4: Comparing Different Versions of Ecological Inference



Note: Each figure plots the estimated percent support for a candidate from each racial group across the elections considered. The 45-degree line is indicated in red. The left panel shows results using ecological inference as in the main text (e.g., Rosen et al. 2001) and the right panel shows ecological inference using the "iterative" procedure (e.g., implemented in `eiCompare`; Collingwood et al. 2016).

Figure 5: Comparing Different Versions of Ecological Inference (District 6)



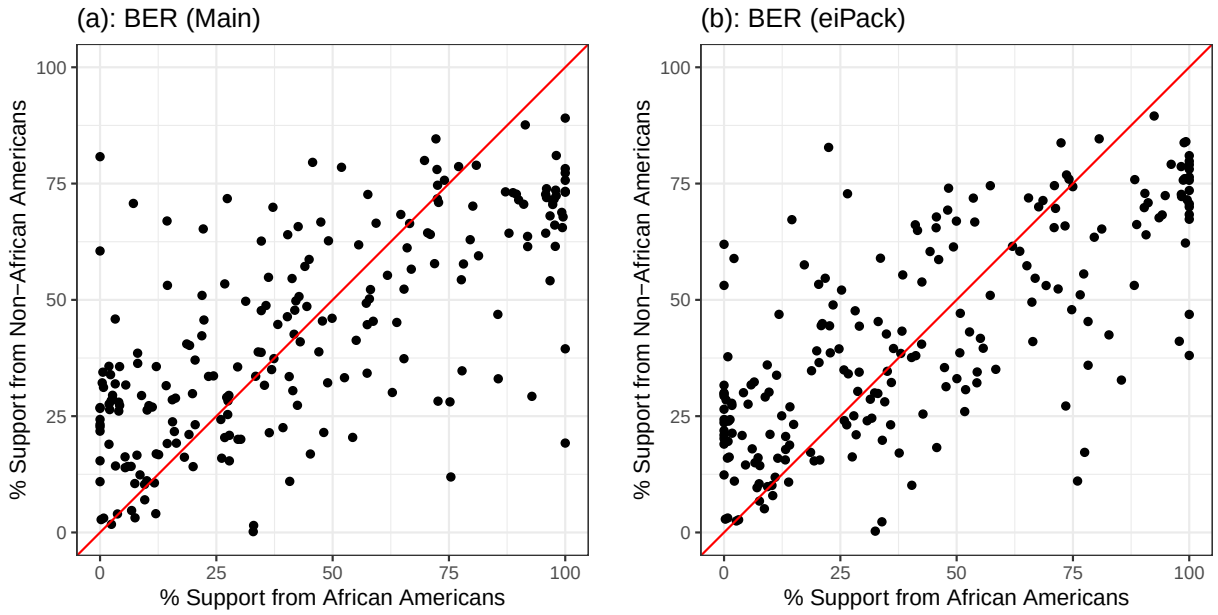
Note: This figure shows the estimates from EI (main text) and EI (Iterative) for each racial group (horizontal panels) and District 6 or not (vertical panels). The 45-degree line is shown in red.

D Different Methods for BER

The implementations of BER differ somewhat between `eiCompare` (reported in the main text) and `eiPack`'s implementation via `ei.reg`. For completeness, these two methods are compared here.

Figure 6 begins by replicating Figure 1. Panel (a) replicates the BER analysis in Figure 6 and Panel (b) shows an alternative version via `eiPack`. Visually, Figure 4 looks quite similar to the main analysis and the correlation between estimates for each racial group (African Americans and non-African Americans) is comparable (0.73) to the numbers reported in the main text for BER (0.69). Recall that the comparable correlations for EI are 0.79 (main text) and 0.74 (iterative).

Figure 6: Comparing Different Versions of BER



Note: Each figure plots the estimated percent support for a candidate from each racial group across the elections considered. The 45-degree line is indicated in red. The left panel shows results using BER as in the main text (e.g., `eiCompare`; Collingwood et al. 2016) and the right panel shows BER using the `ei.reg` function in `eiPack`.

I replicate the second primary table (Table 3) on the most-supported candidate but now include two different versions of BER. The results are similar to the main version of BER, although slightly lower in terms of agreement on most-supported candidate in the primary.

Table 10: Percentage of Elections Where Racial Groups Have Same Most-Supported Candidate

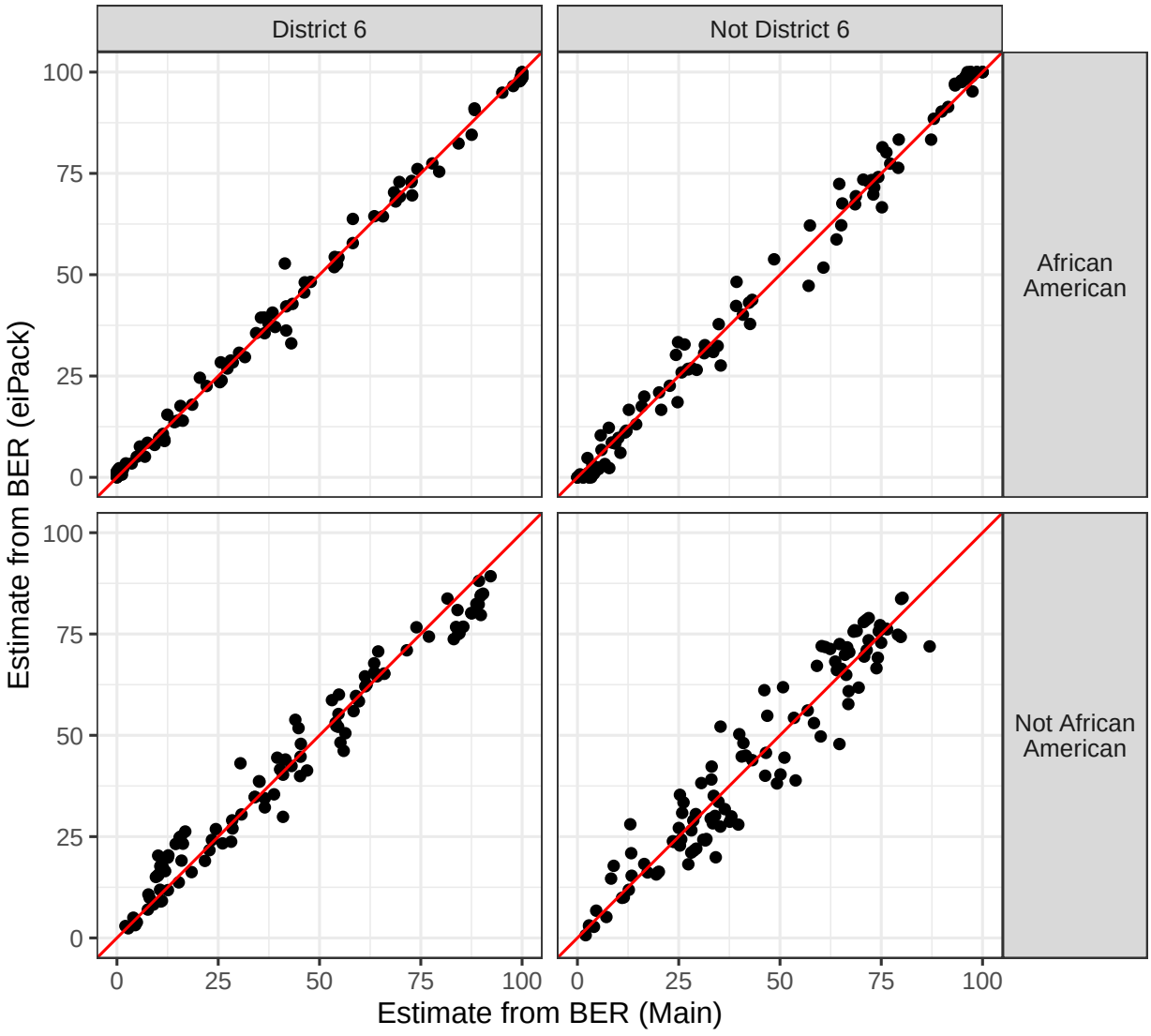
Election Type	Num. of Elect.	% Agree (EI)	% Agree (BER)	% Agree (BER-eiPack)
GENERAL	32	93.8	90.6	93.8
PRIMARY	60	68.3	70.0	63.3

Note: This table reports the percentage of contests where both African Americans and non-African Americans have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support from the group. "Num. of Elect." notes the number of elections considered. The "% Agree" column denotes the percent of those elections where the racial groups agree.

The results for the District 6 analysis are similar between both versions of BER. The relationship

between the estimates across the methods and racial groups is shown in Figure 7; they are highly correlated.

Figure 7: Comparing Different Versions of BER (District 6)



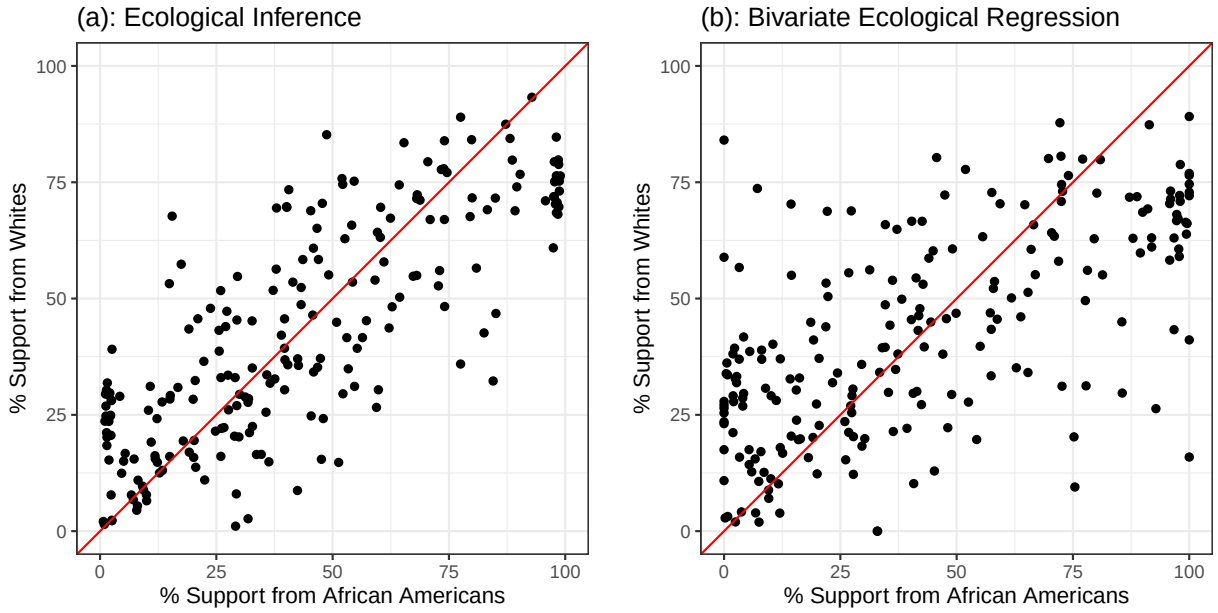
Note: This figure shows the estimates from BER (main text) and BER (`eiPack`) for each racial group (horizontal panels) and District 6 or not (vertical panels). The 45-degree line is shown in red.

E Four Racial Groups

This section re-analyzes the main results using four racial groups (White, African American, Asian, Other) as defined in the Scope of Work. I report results for the White and African American

groups here. As in the main analysis, the correlation between estimated vote decisions for White and African American voters is high for Ecological Inference (0.79), and somewhat lower for BER (0.64).

Figure 8: Support for Candidates by Racial Group (Four Groups)



Note: Each figure plots the estimated percent support for a candidate from each racial group (White and African American) across the elections considered. The 45-degree line is indicated in red. The left panel shows results using ecological inference [EI] and the right panel shows results using Bivariate Ecological Regression [BER].

Examining the most-supported candidate—and when this agrees across racial groups—is also similar to the main analysis. Table 11 replicates Table 3. We see that the results are very similar; in general elections, African American and White voters are overwhelmingly estimated to have the same most-supported candidate. In primary elections, there is more disagreement and around 65-70% of the time the two groups are estimated to share the same most-supported candidate.

Table 11: Percentage of Elections Where Racial Groups Have Same Most-Supported Candidate

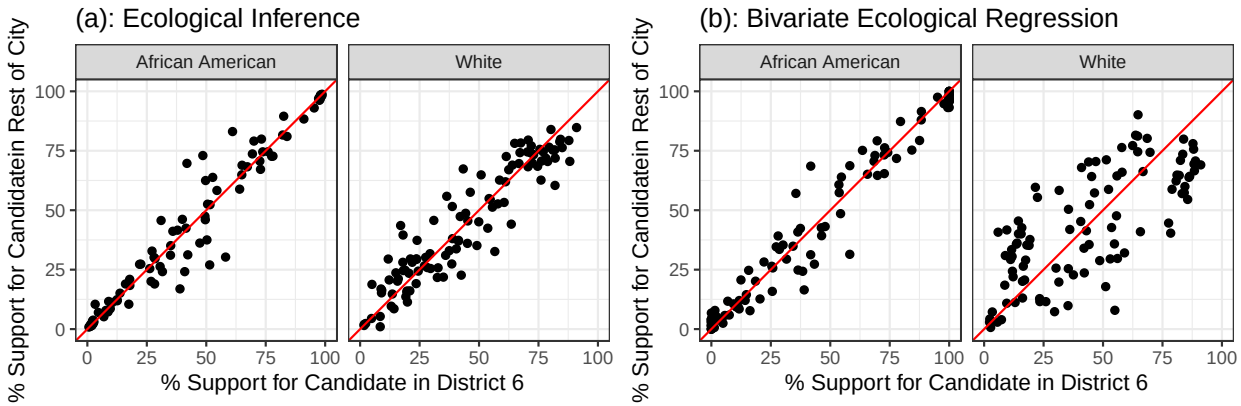
Election Type	Num. of Elect.	% Agree (EI)	% Agree (BER)
GENERAL	32	93.8	87.5
PRIMARY	60	68.3	66.7

Note: This table reports the percentage of contests where both African Americans and Whites have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support from the group. "Num. of Elect." notes the number of elections considered. The "% Agree" column denotes the percent of those elections where the racial groups agree.

When considering the District 6 analysis, the analysis with four racial groups is again very similar to the one reported in the main text. Figure 9 shows the relationship between estimated support between African American voters in District 6 and in the rest of the city and White voters in District 6 and in the rest of the city. The correlation is high for African Americans using either method (0.98 using EI and BER). For White voters, EI estimates a high correlation (0.93) while

BER estimates a lower correlation (0.73). This pattern and estimated values are similar to those reported in the main text.

Figure 9: Comparing District 6 Against Remainder of City (Four Groups)



Note: Each figure plots the estimated percent support for a candidate from District 6 versus the remainder of the City. Each panel shows, respectively, African American and White voters. The 45-degree line is indicated in red. The left figure shows results using ecological inference [EI] and the right figures shows results using Bivariate Ecological Regression [BER].

Next, I report the percentage of races where District 6 is estimated to have the same most-supported candidate as the rest of the City for each racial group. As in the main text (Table 6), there is strong agreement between District 6 and the rest of the city for both White and African American voters for general elections. In the primary, there is more disagreement although the reported levels are broadly comparable to those in the main text—albeit slightly lower for BER and White voters.

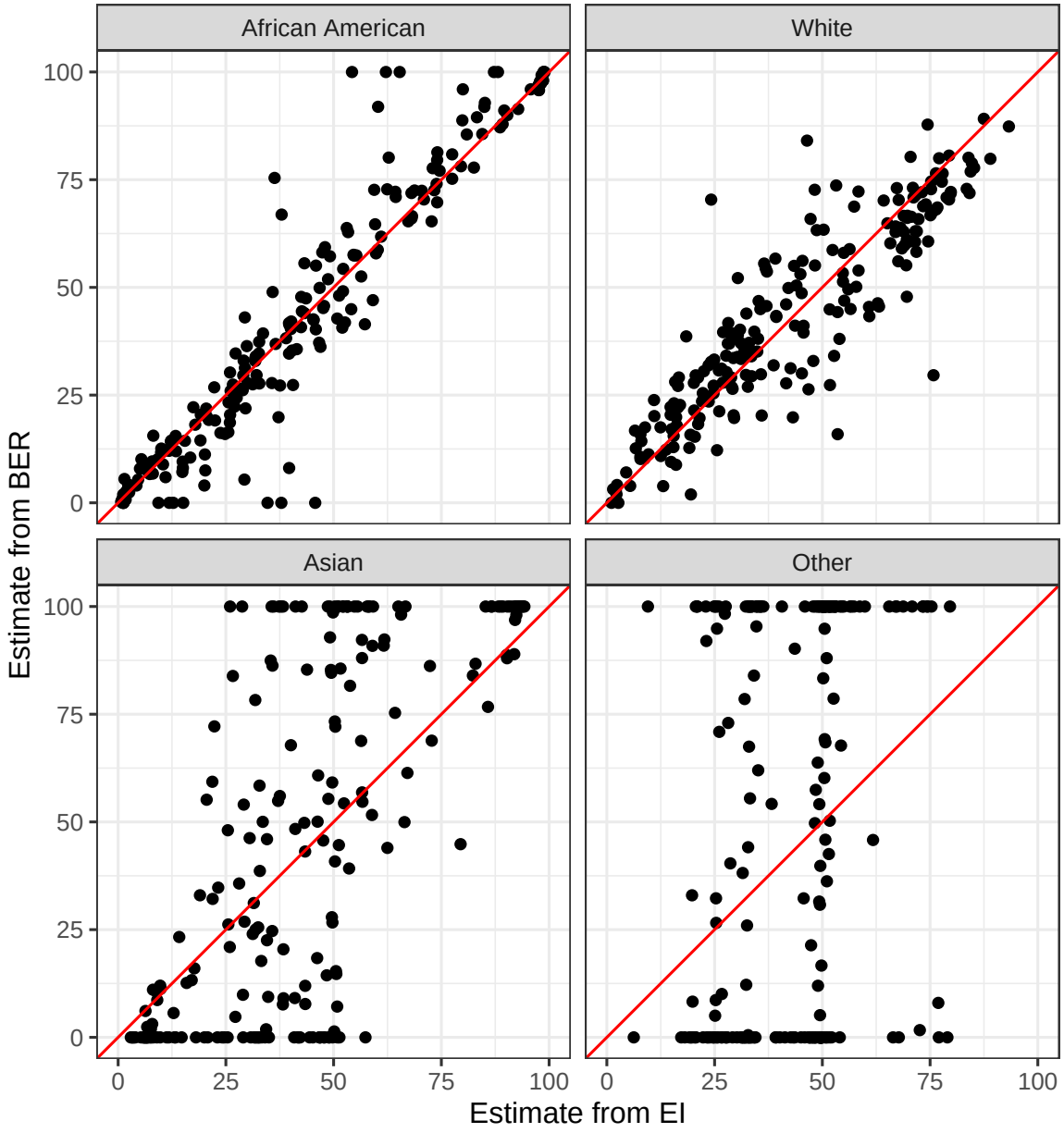
Table 12: Most-Supported Candidate Agreement between District 6 and City

Election Type	Racial Group	EI		BER	
		Num. of Elect.	% Agree	Num. of Elect.	% Agree
GENERAL	African American	21	100.0	20	100.0
GENERAL	White	21	100.0	20	90.0
PRIMARY	African American	26	84.6	24	87.5
PRIMARY	White	26	80.8	24	62.5

Note: This table reports the percentage of contests where voters in District 6 and outside of District 6 have the same most-supported candidate, i.e. the candidate that is estimated to get the highest share of support. "Racial Group" reports the racial group under consideration. For both Ecological Inference (EI) and Bivariate Ecological Regression (BER), "Num. of Elect." notes the number of elections considered and "% Agree" notes the percent of elections where the District 6 and non-District 6 voters have the same most-supported candidate.

Finally, I directly compare the estimates from BER and EI for each racial group and election using the *city-wide* analysis. Figure 10 shows that BER encounters substantial difficulties for estimating the smaller racial groups (Asian and Other). It gives a large proportion of estimates to be either 0% or 100%—suggesting the model rounded estimates outside of that range to the corresponding bound. Thus, these estimates are not especially plausible. By contrast, EI typically returns estimates that are between 0% and 100%. Focusing on the largest groups (White and African American), however, the two methods still return relatively highly correlated predictions (0.90 for White between EI and BER; 0.95 for African American between EI and BER).

Figure 10: Comparing BER and EI (Four Groups)



Note: This figure plots the estimates from EI and BER for each racial group in a separate panel. All candidates and elections are included. The 45-degree line is shown in red.

F Bayesian Diagnostics

The main ecological inference (EI) analysis is done using a Bayesian procedure (see Rosen et al. 2001) that samples from the corresponding posterior distribution. I briefly provide some details on that process here. I use the sampling algorithm from Rosen et al. (2001) implemented in `eiPack` (Lau, Moore and Kellerman 2007; and called via `eiCompare`; Collingwood et al. 2016). After some initial analyses suggested poor mixing, I modified the default settings in Collingwood et al. (2016) to proceed as follows using a single chain: For each model, I perform 100,000 iterations of burn-in. I then draw 1 million samples and save every 10th sample to give a final sample of 100,000 draws for the reported analysis. I also increased the number of tuning runs from 10 to 20. Given the large number of analyses conducted (374), it is difficult to tune each sampler individually. Thus, I chose a number of samples and burn-in that seemed to perform well across the analyses in aggregate.

In terms of the main analysis (city-wide and District 6) using two racial groups, the samplers appear to have converged reasonably well. Using the modified $\hat{R}$ discussed in Vehtari et al. (2021), none of the 187 analyses report any $\hat{R}$ above the threshold of 1.1 across the estimated vote shares for either racial group.

The multiple racial group analysis in Appendix E has more difficulties. Of the 187 analyses, eleven report an $\hat{R}$ above 1.10, mostly ranging from 1.10 to 1.15 with two (2019 District Attorney Primary, 2021 PPS 5 General) having higher $\hat{R}$-s for at least one variable of 1.41 and 1.58, respectively. A majority of the worst mixing is concentrated for the Asian and Other racial groups—for which there is more limited variation in the underlying data.