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Article

Demographic indicators of voter shift between 2016 and 2020 presidential elections

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SUMMARY

Political analysts have long studied demographic shifts through elections, and with the results of the 2020 presidential election, this opportunity comes again. Not only does maintaining an understanding of broad demographic shifts help to understand changing U.S. communities but studying them in relation to electoral changes helps campaign outreach efforts to increase turnout and inform political analysts about future elections. Our study aimed to determine the demographic indicators for voter shift between the 2016 and 2020 presidential elections based on demographic data put through a K-nearest neighbors classification algorithm (KNN) and Principal Component Analysis (PCA). Our original hypothesis was that COVID-19 cases would be the best indicator because the COVID-19 pandemic significantly impacted society. Using the KNN, we found that the employment sector as the best indicator with an accuracy of 67.3% across 893 counties. Alternatively, our results using the PCA showed that the total population was the best indicator. An overarching theme between these two results was urbanity, which heavily influenced both employment sector composition and total population. Notably, we found that race was the poorest indicator, with a 49% accuracy using KNN. Our results indicated a rise in identity politics, a political approach where people form and maintain political views based on social and group identities, which could further be explained by increasing division between urban and rural areas. Additionally, inaccuracies of the KNN raise concerns about the efficacy of contemporary race modeling in predicting voter shift.

INTRODUCTION

The United States electorate has gone through massive demographic shifts in recent years and has grown far more diverse (1). Because of this diversification, it is vital to maintain an understanding of which demographic factors are the most important in voter shift. The year 2020 has been unprecedented for many reasons. Voter turnout was the highest in over a century, with record levels of mail-in voting amid a global pandemic (2). Electorate shifts have been researched extensively between past elections due to the insight they provide into the United States population and communities across the United States (3-8). The results of the 2020 presidential election give an opportunity to analyze the shifts in the last four years.

In past election cycles, the role of minorities has become more critical as their turnout rates have increased and political parties have recognized the importance of targeted messaging towards these groups (9). The United States has a two-party system, which is today composed of the Democratic and Republican parties. Democratic candidates tend to be more liberal while Republican candidates tend to be more conservative, and most voters voted for either the Democratic or the Republican candidate in presidential elections. Minority groups have commonly favored Democrats due to the anti-immigration policies commonly seen from Republican candidates (10). Since 2000, the Democratic vote percentage among minorities has risen, accounting for the most votes in most minority groups (1). In 2000, around 65% of the Latino electorate voted Democratic in the presidential election, but by 2012 this number had risen to 73%, representing an overwhelming majority of Latino votes for Democratic candidates (1). A similar trend was seen for Asian Americans, going from 57% Democratic in 2000 to 73% in 2012, and for African Americans, going from 90% Democratic in 2000 to 93% in 2012 (1). Therefore, race is an essential demographic factor in voter shift. Based on past trends, and as the role and impact of minority populations increases, the votes for Democratic candidates can also be expected to increase.

The urban and rural divide is another vital component in understanding voter shift, as urban areas tend to vote Democratic while rural areas tend to vote Republican (4, 6, 11, 12). In 2018, polling showed that 64% of voters in urban areas supported Democratic policies, while only 38% of voters in rural areas supported Democratic policies (11). The partisan difference in rural and urban areas is widening as well. In 2012, Democrats had a 5% margin over Republicans in urban areas, but by 2018 this margin had increased to 17% (11). This trend is also reflected in rural areas, in which the Republican margin grew from 29% to 38% between 2012 and 2018 (11). As counties across America urbanize, political pundits hypothesize that Republican-dominated states, such as those in the Midwest, will become closely contested as they urbanize (12). The 2020 presidential election in Georgia supported this hypothesis, where the state's electoral college votes were sent to the Democratic presidential candidate for the first time in over two decades (13). Therefore, urban and rural areas are another significant component in the

demographics of voter shifts.

While much of past research surrounding demographics and voter shift has focused on demographic factors such as race or economic status, our study examined the demographic characteristics on a broader scale, analyzing over thirty demographic factors. We aimed to identify the turnout shift between the 2016 and 2020 presidential elections and the demographic factors responsible for this shift. We used an initial set of demographic and election data by county as a baseline for both shift and demographic analysis. To assess the magnitude of voter shift across various counties, we analyzed the political party margin differences. The Principal Component Analysis (PCA) and the K-Nearest Neighbors (KNN) algorithms were applied to demographic data to yield the most important demographic factors. We hypothesized that COVID-19 cases would be the best indicator because of their relevance and significant impact on society. However, this was proven incorrect as our actual top predictor was total population and employment sector composition, though the two are related to COVID-19 cases. The primary contribution of this study is to provide the top demographic indicators of voter shift. A secondary contribution of this study is to evaluate voter shifts of the last four years.

RESULTS

To assess the magnitude of voter shift across various counties, we analyzed margin differences between presidential elections. The data was on a county scale, but because there are over 3,000 counties, the data was averaged through weighted averages to produce a state-level map.

To see the shifts in voter preference between the 2016 and 2020 presidential elections, we used the appended columns of "margin2020", "shift", and "margin2016". The margin and shift data are grouped by state and then put into a map plot (**Figure 1**). Most states had a Democratic shift between the 2020 and 2016 presidential elections. While most states shifted Democratic between the two previous presidential elections, there are notable exceptions to this trend, including New York, a typically Democratic state. States with the most prominent Democratic swing were Connecticut and Rhode Island, with swings of more than 30% in favor of the Democrats. However, most states that shifted Democratic had shifts of between 3-6%. Out of 50 states, only 10 states had a Republican shift, with most of these shifts being around 1-2% (**Figure 2**).

Furthermore, we analyzed the relationship between state population and voter margin shift (**Figure 3**). The population of a state seems to be inversely proportional to the level of voter shift in that state (i.e., states with lower populations tend to have larger voter shifts). A few examples of this relationship include states with smaller populations such as Alaska, Colorado, Connecticut, and Rhode Island, had large voter shifts. On the other hand, states with large populations, such as California, Florida, and Texas, all had rather small

Figure 1. Voter shift from 2016 to 2020 at a state scale. (A) results of the 2016 presidential election, (B) margin shift between 2016 and 2020 presidential elections and (C) results of the 2020 presidential election. Red indicates a Republican win or shift, and blue is a

voter shifts. From a statistical viewpoint, this relationship is somewhat logical, as a single person's decision in a state with low population would have more impact than a single person's decision in a state with high population. As such, an equal amount of people changing sides in both Rhode Island and California would result in vast differences in the voter shift.

Following this, PCA was conducted on American Community Survey (ACS) demographic data, identifying the following top four demographic indicators: total population (all people living in a county), private-sector workers (number of individuals working non-government jobs), drivers (number of people who drive in a vehicle as their primary source of transportation to and from work), and voting-age citizens (total number of U.S. citizens 18 years and older).

KNN analysis was run on the six demographic groupings (**Table 1**). Demographic groups were collections of six recorded demographic factors from the ACS data. The testing sample is 893 counties large, with 416 Democratic counties and 477 Republican counties. Therefore, correct Democratic and false Republican cases always sum to 416, and correct Republican and false Democratic cases will always sum to 477. The KNN model's results show that the employment sector is the best indicator of voter shift in the last presidential election, and race is the worst indicator (**Table 1**).

DISCUSSION

Political pundits have long combined demographic and electoral data to identify and analyze trends in U.S. society and elections. With the 2020 presidential election, this opportunity comes again. In recent decades, top demographic indicators have included racial diversification, greying populations, and socio-geographic divides. Understanding the correlative relations between demographics and electoral shifts helps policymakers and politicians better target campaigning to increase turnout and create better policy that helps voters.

While most states shifted Democratic between the two previous presidential elections, notable exceptions to this statement include states like New York, Alaska, and Maine. A Republican shift in a populous state like New York was somewhat unexpected, as urban areas tend to have better voting margins for Democrats (4, 8, 11, 12). The states with the most significant Democratic swing were Connecticut and Rhode Island, with swings of more than 30% in favor of the Democrats. However, most states which shifted Democratic

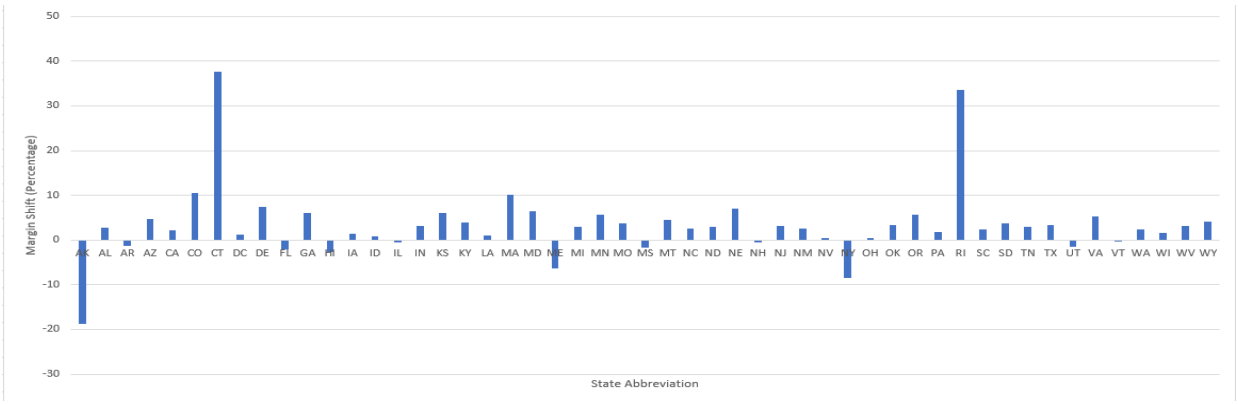

Figure 2. Margin shifts between 2016 and 2020 Presidential Elections by State. The x-axis indicates state (using standard abbreviations), and the y-axis represents margin shifts as percentages. A positive value is a Democratic shift, and a negative value is a Republican shift. The values are calculated as the difference between margins from 2016 and 2020, with margins calculated as the difference between Democratic and Republican votes at a state scale.

had shifts of between 3-6%. Alaska was the only state with a Republican shift of more than 10%, the next closest being New York with a shift of 8%. While an overwhelming majority of states may have shifted Democratic, many of the shifts in states were small, with 14 states having a change of less than 2%. Of those 14, six states had a change of less than 1%, including Idaho, Nevada, Ohio, Vermont, New Hampshire, and Illinois. However, there does not seem to be a pattern between states with small voter shifts.

Furthermore, Democrats also made inroads into Southern states, such as North Carolina, Georgia, and Florida, as the flipping of Georgia marks a milestone for Democratic progress in the South (3, 6, 13). Based on our results, it seems that many previously strong Republican states may become more competitive for Democrats, particularly as areas urbanize. One outlier was New York, which saw a Republican shift even though it is highly urbanized and a traditionally Democratic state.

Based on our results from PCA, total population was the best indicator for voter shift. This result aligns with existing ideas that areas with large populations tend to be more Democratic, while rural areas tend to be more Republican (11). This could result from Democratic policies favoring higher governmental services and spending, which corresponds to the integration and proximity of services seen in urban areas. If it is easier for those in cities to see government spending results, they may be more inclined to support its increase. On the other hand, it is harder for the government to spread out services in areas with lower populations and lower population density. This disparity could lead to people in less populated areas favoring Republican policies of tight spending more.

Furthermore, there is a growing shift towards identity politics, that political alignment is not so much policy-based, but rather culture and group-based (4, 7, 8, 11, 12). Many rural areas form strong group identities over perceived encroaching liberal urbanities that threaten their way of life and vote accordingly. This urban/rural split was enhanced by the COVID-19 pandemic, with larger cities having tighter lockdown regulations, and more COVID cases (14). A state's population seems to be inversely proportional to the level of voter shift in that state (**Figure 2**). As such, states with lower populations tend to have more notable voter shifts. For example, Rhode Island which has a population of 1 million had a voter shift of 33%, and Connecticut which has a population of 3.5 million had a voter shift of 38%. On the other hand, states with large populations, such as California (39 million), Florida (22 million), and Texas (30 million), had relatively small voter shifts, such as California's voter shift of around 3%. This relationship is somewhat logical as an individual's decision in a state with a low population would have more impact than an individual's decision in a state with a high population. For example, if ten-thousand people changed the political party they voted for in Rhode Island, which had around 507,000 votes in 2020, this would amount to about a 2% change. The same ten-thousand voters changing in California, with around 17.5 million votes in 2020, would amount to a 0.05% change.

Our results from KNN support a similar viewpoint, though the best indicator of voter shift based on this analysis was the employment sector. This difference was possibly due to the voter base of the Republican party, which is primarily non-college-educated white people (15, 16). Voters who make up the Republican party's voting base are more likely to hold jobs in construction, production, or service sectors (17). Given the unemployment caused by the COVID-19 pandemic, particularly in industries without a heavy digital aspect, it is reasonable to conclude that COVID-19 hit Republican voters harder with these economic consequences (18). The resulting unemployment could then lead to dissatisfaction with the administration and party switching. Surprisingly, we found that race was a poor indicator of voter shift. With an accuracy of 49%, one could achieve better accuracy by flipping a coin. This inaccuracy was a fascinating result because race has traditionally been one of the top demographic factors (outside party identification) for political pundits to model election turnout (1, 10). The poor accuracy of race as an indicator of voter shift shows its limitations in election modelling over time.

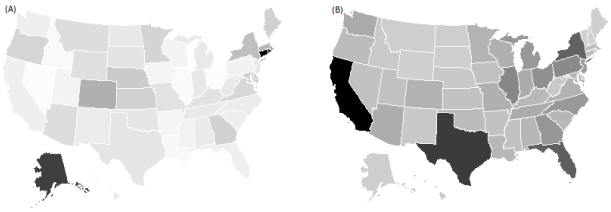

Figure 3. Voter shift in comparison to total population by state. (A) The voter shift by state between the 2016 and 2020 presidential elections. (B) Total population by state on a gradient. Darker colors indicate larger state populations and lighter colors indicate smaller state populations. Total population compiled as a sum of all counties in a state and set on a gradient of white to black. Voter shift map was calculated as the absolute difference between margins in 2016 and 2020. Black indicates larger voter shift and lighter colors indicate smaller voter shift.

Group	Correct Democratic	Correct Republican	False Democratic	False Republican	Accuracy
Population	232	340	137	184	64.1%
Race	173	264	213	243	49%
Income	232	296	181	184	59.1%
Sector	261	340	137	155	67.3%
Transportation	235	275	202	181	57.1%
Work	207	254	223	209	51.6%

Table 1. Results of KNN on various demographic groupings. Table shows accuracy of demographic groupings after application of KNN classification algorithm on data. A False Democratic is when the model predicted a Democratic shift but there was a Republican shift. A False Republican is when the model predicted a Republican shift but there was a Democratic shift. Accuracy calculated as the proportion of correct estimations over the total test group (893 counties).

Rows	Type of data	2016 election	2020 election	Demographics
1 - 3110	County	Yes	Yes	Yes
3111 - 4658	Extra Districts	No	Yes	No
4659 - 4689	2020 Alaska Election data	No	Yes	No
4690 - 4838	Unassigned values	No	Yes	No
4839 – 4868	Alaska demographic data	No	No	Yes

Table 2. Structure of the data. Table shows the resultant combination of various datasets and presence or lack thereof of three necessary components: 2016 election data, 2020 election data, and demographics data. Data was retrieved from the American Community Survey.

Race may be a poor indicator because of the nuances it misses in logging data. Ethnic groups measured were Caucasian, African American, American or Alaskan Native, Asian or Pacific Islander, and Hispanic. Not all ethnic groups share the same political ideology within, so the generalizations fail to account for the nuance within these groups. For instance, Puerto Ricans traditionally vote Democratic, while Cubans traditionally vote Republican, but both are grouped as Latino (19, 20). Furthermore, race data used modeled the population of the county at large and not the voting population. Thus, counties could have a sizable nonwhite population but one that cannot or does not vote.

A unifying theme for the best indicator between the two methods was urbanity. However, to clarify, the indicator of voter shift was a lack of urbanity; rural areas showed higher voter shifts between the 2016 and 2020 elections. Voter shift was inverse to total population, supporting the PCA analysis (**Figure 2**). As urban areas have large total populations, their opposite, rural areas, had greater voter shifts. Furthermore, differences in employment sector composition are seen between urban and rural areas, where urban areas have greater tech, commerce, and service industries than rural areas, supporting the KNN analysis.

Aside from the significant socioeconomic differences in areas such as education, wealth, and employment, there is a growing trend in a group identity divide brought on by the rise in identity politics which furthers the application of urbanity as a shift indicator (4, 7, 8, 11, 21, 22). There is some resentment among rural areas of the "liberal elite", an idea that those living in urban areas look down on rural residents and that urbanities are out of touch with the real needs of rural communities (25, 26).

In this study, we analyzed a set of demographic data with PCA and KNN to determine the most accurate indicators of voter shift between the 2016 and 2020 presidential elections. In analyzing voter shifts, margin calculations showed that most states became more Democratic over the last four years, with an average margin shift of 3% at the state level. PCA yielded total population as the best indicator, and KNN yielded the employment sector as the best indicator. These two factors have an overarching theme of urbanity: how urban an area is being the best indicator of voter shift. Another interesting finding was the inaccuracy of race as an indicator, shown by KNN, which highlights its overlooking of voting rates and diversity among racial groups.

Some limitations remain to be addressed in future research. The demographic data was from 2017. Therefore, various factors, such as the number of employed citizens, are likely inaccurate. Furthermore, there were around 70 missing counties from the data, and complete analysis for states like Alaska and Vermont was not possible because of recording discrepancies in the naming of the county. The results from our analysis raise exciting questions about the future of voting trends in the United States. The impact of urbanization and diversification remain critical topics, as do their implications for understanding and predicting future voter shifts.

MATERIALS AND METHODS

Data and Data Preparation

The primary dataset used was drawn from Kaggle, called "Election, COVID, and demographic Data by County" (23). This dataset combined election data by county with demographic factors from the 2017 American Community Survey 5-year estimate (24, 25). This dataset initially consisted of 51 columns describing the voting trends and demographics of each United States county. We specifically chose this dataset because of its combination and variety of data, as it had combined datasets from various sources and kept formatting consistent

for ease of access. Columns one through three give a number, a name, and a state to the county in an abbreviation. Columns four through eight describe the results of the 2016 election, giving the percentage of votes each candidate received, total votes, and votes for each candidate (as a value instead of a percentage). Columns 9 - 13 describe the same factors for the 2020 election. Following this, columns 14 and 15 give the latitude and longitude of the county. All other columns (16 - 51) describe demographic factors of the county regarding subjects such as race, employment, income, transportation, and COVID-19. Before any alteration, the dataset consisted of 4,868 rows and 51 columns.

There were many extra districts and unassigned values in this dataset, which were not helpful because they were missing data and were not at an accurate scale of analysis. Because they were not counties, they were missing all demographic data, as the American Community Survey only recorded data for counties (23). Therefore, the extra districts had to be removed from the dataset, as they would be problematic in analysis and mapping. This cleaning was generalized to remove any rows with missing data. However, data for Alaskan counties were spread out over hundreds of rows due to the name-recording discrepancies. Alaskan counties were split into two groups, one with demographic data and one with 2020 election data. Therefore, the data for Alaskan counties had to be condensed before the removal of empty data.

Furthermore, presidential election data from 2016 for Alaskan counties was not present in the original dataset and had to be found and added in, using the Alaskan government's website (26, 27). Data for Alaskan counties were then combined into a complete dataset, although a few counties were still missing due to naming discrepancies. With the data for most counties present, any rows with missing values were removed from the dataset. Removal of rows with missing data cut the dataset from 4,868 rows to 3,039 rows. While some counties were missing from the resulting dataset, 3,039 of 3,110 counties account for an overwhelming majority.

Before PCA, the demographic data needed to be standardized, as several columns were recorded as percentages while others were as numbers (24). This inequality would affect the component analysis, and therefore, all the percentage data had to be converted to numerical data. Finally, packages were imported into the model. This model was constructed in the programming language R using the RStudio development environment. Packages used with the model were maps, usmap, gridExtra, and tidyverse.

Margins were calculated based on voting data for both presidential elections to analyze the voter shift. Three new columns were added to the data to represent margins and shifts: "margin2016", "margin2020", and "shift". Columns "margin2016" and "margin2020" are calculations of the winning margin in each county by-election. However, these two margin columns do not follow traditional methods of margin computation, as it was necessary for them to indicate the degree of the victory and the party that won. Instead of taking the absolute value of the difference, as is traditionally done, margins for the two columns were simply the difference between the percentage of Democratic votes and the percentage of Republican votes as Margin = Democratic-Republican (28). Therefore, margin values ranged from one to negative one, in which a number closer to one indicates a decisive Democratic win, while a number closer to negative one indicates a decisive Republican win. The "shift" column was then calculated based on these two margin columns, as it would show a strengthening or weakening of a party's presence in a county. The "shift" column was represented from a scale of two to negative two and calculated as Shift = margin2020 − margin2016. A value closer to two represented a substantial Democratic shift, while a value closer to negative two represented a substantial Republican shift. The drawback of the "shift" column is that it cannot portray whether a particular county switched parties, but it is valuable for looking at the trends over time.

PCA and KNN

We used both PCA and a KNN classification algorithm to analyze the data. PCA is a dimension reduction technique that emphasizes variation in bringing out the patterns of a dataset. It finds the relationships between columns of variables and produces Principal Components (PC), which reflect the importance of the variables. For each variable (column) in a dataset, a PC is created. Earlier PCs, such as PC1 or PC2, generally contain the most variance, and by finding the factors which make up those PCs, the best indicators are found (29). To determine the best indicators, PCA was run on all 36 demographic factors in R. Variance was calculated off the square of Standard Deviation, to find the best PCs (typically PC1 and PC2). The two PCs were then plotted with all demographic factors, and the factors with the largest values were the best indicators.

The KNN classification algorithm is a machine learning model used for classification and regression based on K-number of clusters, used to group data for regression. The 36 columns of demographic data were split into 6 groups: population, race, income, employment sector, transportation, and work (private, public, self-employed). A KNN model with three clusters was run on each of these groups, the most accurate group being the best demographic indicator of shift. Three clusters were chosen as the cluster number because it had the highest accuracy in predicting outcomes for the data at large after testing clusters from one through ten.

The usmaps package was used to create various maps for a graphical representation of the data (30). Existing election and demographic data were combined with a Federal Information Processing Standards (FIPS) dataset for accurate plotting, as the usmaps function used the FIPS IDs to graph the counties. The result was a new dataset of the mutual counties, in which each county now has a corresponding FIPS code for plotting. This new dataset had 3031 rows.

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