The Road to Division: Interstate Highways and Geographic Polarization

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Abstract

What explains geographic polarization, the tendency of individuals to live near their fellow partisans? In particular, what explains the tendency of voters to sort into Democratic urban and Republican suburban and rural areas? Existing sorting models attribute sorting either to individual-level preferences or to discriminatory public policies. This article considers an alternative explanation: public policies that stimulate mobility increase sorting. Combining Interstate Highway System construction data with county-level presidential election results, I show that suburban counties with Interstates became more Republican than they would have been in their absence. I then show that metropolitan areas with greater highway density became more geographically polarized than comparable areas with fewer highways. These findings demonstrate that public policies can change American politics not only by influencing individual behavior, but also by influencing citizens’ geographic distribution.
The separation of Democrats and Republicans into urban and suburban/rural enclaves is a defining feature of American politics, but remains, along with other questions in political geography, one of the unsolved “open questions” in studies of the major rifts thought to split the American electorate (Fiorina and Abrams 2008). Previous scholarship has made feints toward measuring and explaining the partisan geographic divide nationally (Glaeser and Ward 2006), within states (Cain, Hui and Mac-Donald 2007), and between Congressional districts within metropolitan regions (Theriault 2008), but have not attempted to isolate the historical causal mechanisms that have created these patterns. Others have focused on the more general sorting of Americans into lifestyle-focused communities that correlate with partisanship (Bishop 2008). However, little published work has sought to isolate the origins of Democrats and Republicans’ persistent tendency to sort along an urban-suburban continuum, even as it persists as one of the most salient forms of geographic polarization.1

One need only look at the now familiar population-adjusted maps of presidential election results to observe that urban-suburban polarization is a nearly universal pattern. Figure 1 modifies the familiar cartogram of 2008 presidential election results to highlight only counties that fall within 80 kilometers of the 100 largest cities; other counties are grayed out.2 In nearly every metropolitan area, large Democratic cities appear as big blue (Democratic) islands, surrounded by the redder sea of more Republican suburban counties (Figure 1). This is true in more Democratic metropolitan areas such as New York City and in less Democratic areas such as the Dallas-Fort Worth area.

1I interchangeably use the terms “geographic polarization” and “partisan geographic sorting.” The latter suggests a dynamic process, while the former suggests a static geographic pattern, but many empirical implications are the same.

2The list of largest cities is based on 1950 population, the sampling frame selected to track urban-suburban polarization over time.
Figure 1: Cartogram of the 2008 presidential two-party vote in major metropolitan areas, displayed on the familiar red-blue continuum from Republican to Democratic. County size is proportional to the total vote. To highlight red-blue divide in metropolitan areas, the 100 largest cities as of 1950 and counties within an 80-kilometer buffer appear in bold. For reference purposes, the Dallas and New York City areas are labeled.
This geographic pattern is worth explaining not only because it leads to different spatial distributions of voters, but because local geographic homogeneity may change both the aggregation of preferences and may create new political contexts that influence behavior. The concentration of Democrats in high-density urban areas and Republicans’ dominance of low-density rural and suburban areas may hurt Democrats by biasing redistricting plans in favor of the Republicans (Chen and Rodden 2009). Partisan sorting may also contribute to political divisions between local governments as voters sort into homogeneous communities that may increasingly represent the particular interests of their electorates (Teaford 1979) while transforming contests among citizens into institutional disputes between local governments (Oliver 2001 Ch. 8). Concentrating individuals with similar interests and ideologies in the same place can also generate additional political extremism deriving from neighborhood and community solidarity. Gould (1995) shows that Baron von Haussmann’s reconstruction of 1850s Paris gave rise to stronger, neighborhood-based class identities among workers who were relocated into suburban housing projects. The “new suburban history” has similarly suggested that postwar suburbanization in the United States stimulated the formation of place-based class identities in places like Orange County (McGirr 2001) and the suburban South (Kruse 2005; Lassiter 2006) that stimulated development of the modern conservative movement in newly built middle-class neighborhoods. Conversely, the absence of geographic concentration of residents may undermine solidarity and bloc partisan voting. Fenton (1966), for example, suggests that a reason for the Republican Party’s success in Ohio was the geographic dispersal of the working class and the concomitant challenges to party and union organizing. Individual-level observational and laboratory research suggests that contextually induced changes in partisan attitudes may result from increased exposure to politically homogeneous discussion networks (Mutz 2006; Sunstein 2009).

Rather than attempting to arbitrate among the numerous causes of urban-suburban polarization, this paper isolates and tests one substantive hypothesis about American partisan geographic sorting: that fed-
eral public policy has remade American metropolitan areas and changed the American partisans’ spatial distribution. This article considers the enduring consequences of one of the most important of these mobility-enhancing policies (and the largest public works project in American history): the Federal Aid Highway Act of 1956, widely known as the Interstate Highway Act. Highways built under the Act helped grow American suburbs (Baum-Snow, 2007), in the process extending Americans (white Americans, in particular) more employment and housing options within their metropolitan areas. I show that these changes were more than economic, they were also political. I begin by proposing a model capturing the circumstances under which transportation networks may facilitate sorting. Combining presidential election results from the previous half-century with Interstate highway construction data, I show that Interstate highways facilitated the creation of Republican suburbs and, as a related consequence, facilitated the urban-suburban partisan divide in the presidential vote. I present evidence for these claims in two separate but related analyses. In the first set of analyses, I merge historical data on Interstate highway construction with county-level presidential data, then apply data-appropriate matching methods (Iacus, King and Porro, 2009, 2011; Diamond and Sekhon, 2005) with difference-in-difference analysis and linear regression to demonstrate that Interstate highways contributed to a decline in the Democratic share of the presidential vote in suburban counties where they were built. Then, in a separate analysis aggregating the same county-level data into metropolitan urban and suburban regions, I show that the urban-suburban gap in the presidential vote is larger in areas with more metropolitan areas with more Interstate highways have developed a larger urban-suburban gap in the presidential vote than comparable metropolitan areas with fewer highways. An additional analysis of underlying changes in county economic and residential patterns suggest that highways may have driven partisan change by facilitating localized construction of new housing and increasing the average income in suburban counties where highways were built (through migration or economic development). However, these differences among
suburban counties appear do not extend to highways’ effect on the urban-suburban gap. Evidence from an additional analysis shows that that highways increased the urban-suburban gap in non-white racial composition and dwelling age, suggesting, that by enabling white flight to new suburban neighborhoods, highways added to the urban-suburban partisan gap. I discuss these findings’ implications for research on both partisan geographic sorting and policy feedback.

1 How Transportation Infrastructure May Facilitate Sorting

One of the unexplored factors governing residential sorting is the role of transportation networks as a determinant of residential location and its impact on partisan geographic outcomes. Transportation infrastructure, in particular, collapses relational space and modifies the calculus underlying individuals’ residential choices (Gatrell 1983, Ch. 3, White 2011, Ch. 4). To emphasize that the Interstate Highway System is not sui generis, here I conceive of transportation broadly as any program that changes the pace at which people, goods, services, and even information move between places, which encompasses forms of transportation ranging from railroads and highways to postal services and the Internet (Moss 1998). As these networks connect with different places, they can be expect to shape the redistribution of goods, individuals, and political content. Scholarship on the information-distribution networks suggests that their design is crucial in facilitating political change, whether this occurred through distribution of political pamphlets through the 19th century post office free delivery system (John 1995) or through individuals’ selection of homogeneous content on niche broadcast programs (Prior 2007).

Despite prior work on the indirect role of information networks in political behavior, contemporary accounts of partisan sorting tend to ignore transportation networks altogether, arguing that the “clustering of the like-minded,” like other segregation processes, is an emergent property of individual residential choice. The classic model of residential sorting (the Tiebout sorting model) suggests that individuals
choose their neighborhoods by aligning their preferences with the multidimensional features offered by autonomous communities (Tiebout, 1956). Similarly, models of residential segregation have tended to explain residential sorting from one of two reified perspectives. Schelling (1971) argues that segregation can be explained by the aggregate level manifestation of individual preferences; even in the absence of discriminatory policies, individuals with even slight preference for homogeneity will, in the aggregate, produce segregation. Critics of the Schelling model suggest that racially and economically discriminatory policies have induced segregation by limiting residential choice (Massey and Denton, 1993).

While acknowledging the utility of traditional explanations of residential sorting, my account supports a third reason that Republicans and Democrats may settle in different communities: transportation networks may reduce the cost of living in homogeneous communities by subsidizing travel costs. This expands substantially on the Tiebout sorting by demonstrating that policy choices well above the local level shape residential choice. For example, under the Tiebout model a town with a strong public school system, low crime, and affordable land would appeal to a particular type of household (perhaps families with young children). Without easy transportation access to outside communities, neither place is likely to attract the many residents who hope to maintain economic ties to other locations. However, if a major state or federal highway were built nearby, the town might attract residents who demand certain types of public and private goods (Campbell and Hubbard, 2009). Such residents would bring with them partisanship and ideology consistent with these other preferences.

Adding to previous non-spatial approaches to sorting decisions, I present a descriptive model in

3Previous research (e.g., Peterson 1981) has already demonstrated municipalities’ limited control over their local policies and their limited ability to set important economic policies. However, similar work has rarely accounted for the role in state and federal transportation policy as a factor in residential choice.
which transportation networks shape Tiebout or Schelling-style sorting decisions. Emulating the practice of transportation planners, this model defines a transportation network as a set of nodes (the communities into which individuals sort) and edges, the transportation connections between nodes. Each edge in the network can be interpreted as the transportation link connecting two communities. Each node is defined by the attributes of each community, while each edge is defined by the attributes of the transportation mode constituting the link. As individuals choose a residence, they move along the edges between the nodes. Following Tiebout (1956), individuals select communities that match their personal preferences, but also consider other costs associated with residence in the community, including commuting costs. With respect to the sorting of Democrats and Republicans into separate communities, the existence of three key factors may shape these decisions:

- **Homophily**: The primary factor underlying sorting is individuals’ preference to live in communities in which people share the same traits. Even if individuals are not consciously motivated by the desire to live with fellow partisans, this homophily may be expressed through selection on other correlates of partisanship, including race (Schelling, 1971), income, and lifestyle (Bishop, 2008).

- **Discriminatory Gatekeeping**: Communities may influence homophily-driven sorting by selectively admitting residents. Local housing policies that indirectly control community access on the basis of income or home value (Levine, 2006) can be expected to produce consequences for communities’ partisan composition. Before court decisions and statutes prohibiting redlining and racial restrictive zoning and deed covenants, these discriminatory measures would have played a similar role (Massey and Denton, 1993) and would have indirectly shaped communities’ partisan composition.

- **Network Bandwidth and Selectivity**: Different aspects of the connections on a transportation
network may influence how individuals migrate from one place to another. Increased bandwidth on a transportation network edge (e.g., additional lanes on a highway) may subsidize the trips of automobile commuters driving between residential and commercial districts. One possible consequence is that homophily-driven sorting may occur more rapidly along the edge. Sorting may also vary with the transportation mode along each network edge due to socioeconomic differences in transportation usage (Pucher and Renne, 2003). For example, buses and light rail, currently disproportionately used by blacks and the poor, may facilitate residential migration of Democratic-leaning groups. Highways and commuter rail, on the other hand, are disproportionately used by the middle and upper class commuters and might be expected to subsidize the residential mobility of Republicans.

While this model of sorting in the presence of transportation networks explains how citizens may change residence, it does less to explain why the partisanship of places is so durable. Barring major realignments, initial settlement of places often durably establishes a place’s partisanship as expressed through voting behavior (e.g., Gimpel and Cho 2004). While public policies’ temporal durability varies (Patashnik, 2008), transportation projects are “literally cast in concrete” (Pierson 1993, 609), producing stable conditions for the physical construction of new communities. Among other durable changes, transportation projects increase the appeal of new construction in adjoining areas. Highway construction especially contributes to new “greenfield” developments, where real estate developers and related “entrepreneurs” may build communities to serve particular interest and lifestyle groups (Burns 1994, 35-37). The partisan differences induced by transportation programs establish settlement patterns along transportation corridors that persist even after the original transportation network has decayed or disappeared (Chen and Rodden 2011). This permanence of transportation-induced development is a critical causal mechanism giving rise to observed geographic differences. Beginning in the 1930s, the dominant
regime involved government-supported construction of new homes in white neighborhoods; under this regime, construction of highways opened new suburban housing to whites, while racial minorities were typically excluded. Even as this racial-spatial regime has declined (Cutler, Glaeser and Vigdor 1999), the resulting geographic pattern has persisted (Massey and Denton 1993 49-59). Because these demographic biases in to correlate with partisanship, facilitating Republican growth in both suburban counties and in suburban regions with more Interstate highways.

The remainder of this article presents two observed effects on American political geography that are consistent with this model of transportation-induced partisan sorting. First, given the mechanisms described above, one would expect to find that highways have increased the Republican vote share in suburban counties where they were built, as they differentially channeled white flight to different areas in the metropolitan periphery. An analysis using county-level data and an official database on completion of the Interstate highway system, demonstrates that suburban counties in which Interstate highways were built became less Democratic than they would have been otherwise. Using contemporaneous survey and Census data, I suggest several mechanisms underlying this partisan sorting, the primary one being economic sorting as measured through home prices and income. The second analysis, applied to a data set of 73 metropolitan areas constructed from the same county data, conveys a related consequence of this highway-induced suburban growth: a larger urban-suburban divide in metropolitan areas with higher highway density, as measured by the density of Interstate highway connections to local street networks.

2 Highways and Suburban Political Development

The first set of empirical analyses examines the localized effects of highways on suburban political development by linking a historical database on Interstate highway construction covering the years 1956 to 1996 with historical county-level Census and presidential election returns for the years 1952-

2.1 Data and Methods

Population: Using a coding rule, I define counties in the metropolitan periphery as the population of interest. Suburban counties are defined as those with geographic centroids between 20 and 100 kilometers from the center of the 100 largest cities in 1950. Under this rule, the national sample contains $n = 990$ counties, which appear in the map in Figure 2. Counties in which an Interstate highway was built at any time before 1996 appear in gray, while counties without Interstate highways appear in black. To exclude urbanized counties that may have fallen within the catchment area of large cities (e.g., Kings County, New York or Middlesex, Massachusetts), the sample excludes counties with a 1950 population greater than 300,000. Summary statistics for these counties appear in Table 1.

One would typically prefer to draw inferences about American metropolitan political geography using data from the lowest level of aggregation available that is also appropriate to the purpose at hand. Following these two criteria, this study uses county-level data. Though county size varies across states, county spatial resolution is usually sufficient to place counties on an urban-suburban-rural continuum, and their use in political science has been widely accepted (e.g., McCarty, Poole and Rosenthal [2009]; Hansford and Gomez [2010]; Gasper and Reeves [2011]). The stability of county boundaries enables the multi-decade causal analysis conducted here.

4 Appendix section A.1 tests the sensitivity of these findings to various sample definition rules.

5 While historical precinct-level data would be a desirable data source, their sparsity across the historical period of interest limits their utility for this study. One exception, the Record of American Democracy (ROAD) data, provides spatial resolution at approximately the municipal level for elections between
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
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<td><strong>Treatment Variables</strong></td>
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<td>Earliest Interstate Opening, (Treated Counties)</td>
<td>1965</td>
<td>6.717</td>
<td>1942</td>
<td>1992</td>
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<td>Interstate Highway Built At Any Time</td>
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<td>0.192</td>
<td>0.006</td>
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<td>0.164</td>
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<td>199.2</td>
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<td>Region=South</td>
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<td>0.49</td>
<td>0</td>
<td>1</td>
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Table 1: Summary statistics for suburban county sample ($n = 988$).
Figure 2: Map of the suburban county sample. Counties that contained an Interstate highway at any point appear in gray, while counties without Interstate highways appear in black.

_Treatment Variable:_ For each election year $t$ and county $i$, a binary treatment variable $Z_{it}$ indicates whether an Interstate highway passed through county $i$ by year $t - 4$, constructed from the Federal Highway Administration PR-511 database, the only rigorous year-to-year record of the construction of interstate highways and the incorporation of existing freeways into the system (Baum-Snow [2007], Michaels [2008], Chandra and Thompson [2000]). Two aspects of the Stable Unit Treatment Value Assumptions 1984 and 1990, but only for states in the country’s northeast quadrant. Similar databases of precinct-level results from recent elections have been collected recently (Ansolabehere and Rodden [2011]). Leveraging these data to establish causal effects across the time period of this study would require heroic missing data assumptions to estimate causal effects and would probably introduce bias through measurement error on imputed covariates.
sumption (Rubin, 1986) are relevant to this coding decision. Any county with an Interstate highway in place for at least 4 years is assumed to receive the same treatment dosage, regardless of actual treatment duration. This is a plausible assumption considering that most counties entered the treated group in a narrow 14-year window between 1956 and 1970. The binary treatment also assumes that all counties with at least one open Interstate highway received the same treatment. An additional component of this assumption is that no interference occurs between units, so that the realized treatment of unit \( i \) for all \( i \) has no bearing on the outcomes in unit \( j, i \neq j \).

Outcome: The outcome of interest is the difference in the county-level Democratic presidential vote share between 1952 and election year \( t, t \in \{1960, 1964, \ldots, 2008\} \) is the outcome of interest. Recent research suggests that the presidential vote is a suitable proxy for an area’s latent partisanship (Levendusky, Pope and Jackman, 2008).

Covariates: While previous suburban politics research has applied multivariate regression using cross-sectional data (Williamson, 2008; Gainsborough, 2001), which permits effective descriptive inferences, this study selects covariates to respect the temporal ordering of the treatment and outcomes, using a number of Census and political variables from before passage of the Federal-Aid Highway Act of 1956 to avoid introducing post-treatment bias. Two strong correlates of county partisanship included in the regressions are Percentage nonwhite and a categorical measure of Median family income in 1950. Other indicators of the population growth trends and county urban development include Log persons per

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6Presidential election returns are taken from the ICPSR county-level presidential election returns data (Clubb, Flanigan and Zingale, 2006; Inter-university Consortium for Political and Social Research 1995). Data for 1992 to the present, and corrections to ICPSR errors were drawn from CQ Press (2010) and Leip (2010). The approximate location of the central business district is defined using the point location of the “cities” layer in StreetMap USA.
acre, the Number of small farms and Crop value per capita (a measure of rurality that may capture the amount of land suitable for development), and a categorized variable for the Percentage urban, a measure of preexisting development. To account for suburban residential mobility at baseline, the regressions include the Percentage of households that lived outside the county in 1949, an indirect measure of the pre-existing suburbanization rate. Three additional controls included to reduce bias between the treated and control units are the Republican percentage of the vote in 1948, 1952, and 1956. By including these three elections, the regressions capture much of the variation in subsequent county-level vote choice, especially those associated with subsequent sectional realignments. The South and treatment variables are interacted to permit reporting of variable treatment effects by region.

**Estimation:** I independently estimate Interstate highways’ effect on county-level Democratic presidential vote share in each election by least squares regression for each election year $t$ between 1960 and 2008:

$$ Y_t - Y_{1952} = \beta_0 + \beta_z z_t + \beta_1 x_1 + \ldots + \beta_k x_k + \epsilon $$

where $z_t$ is the vector of treatment indicators constructed for each election year. The linear model is assumed to correctly capture the relationship among the variables. For $\beta_z$, to capture the causal effect of the treatment of interest, the model assumes that the units in the treatment group undergo the same average potential changes in presidential vote choice over time as units in the control group, conditional on the included covariates. If this assumption holds, this difference-in-differences estimate is a robust approach to causal estimation.

To construct accurate confidence intervals, a non-parametric procedure is followed. The sample Census data were obtained from the National Historical Geographic Information System database (Fitch and Ruggles, 2003).
is bootstrapped and estimates generated for all years on each bootstrapped sample. A lowess curve (Cleveland and Devlin, 1988) is drawn through each set of estimates, and the appropriate quantiles of the smoothed values used to construct the 95% and 80% confidence intervals. This procedure borrows information across multiple elections and smoothes across election-specific idiosyncrasies, generating an estimate of highways’ impact in a handful of adjoining years. This nonparametric approach remains close to the data and avoids the functional form assumptions of multi-level models.

To test the robustness of these findings to regression modeling choices, generate a more balanced sample using coarsened exact matching (CEM), a completely nonparametric alternative to propensity-score matching (Iacus, King and Porro, 2011a; Ho et al., 2007). This matching method places observations in multidimensional bins according to coarsened covariate values, then assembles a sample from the treated and control observations appearing in the same bin. The default procedure in CEM is to trim both treated and untreated observations from the sample, possibly generating a more balanced sample when covariate overlap is minimal than methods that only discard control-group or treated-group units. CEM is applied to the sample for each election year. While imbalance between the treated and control groups is only partially reduced in the early years of the Interstate program, CEM removes almost all of the imbalance on observed covariates in later years. The standardized imbalance for the treated and untreated groups—the difference in means for each variable between the treated and control groups, divided by the standard deviation of each variable in the treated group—appears in the Online Appendix, Figure A-6.

Unlike propensity-score methods, CEM allows for matching on covariates that are not normally or $t$-distributed while avoiding the introduction of bias (Rubin, 1976).

Along with the matching procedure, the sample is truncated to exclude “early-adopter” states that built Interstate-quality highways before passage of the 1956 Highway Act. For example, the Mas-
Like all observational studies (except natural experiments), this approach has several limitations. First, one possible limitation is that the analysis suffers from hidden sources of bias. To ameliorate this concern, I conducted a placebo test, using the 1952 presidential vote as the outcome variable for each of the independent annual estimates. Under such placebo tests, failure to reject the null for the baseline effect is held to affirm unbiasedness. Placebo regressions on the CEM-matched sample yield point estimates close to zero, as desired, and the 80% and 95% confidence intervals overlap with zero.

While the combination of difference-in-difference, matching, and regression techniques is a robust approach to causal estimation, one necessary shortcoming of this study is that the variables used in the analysis do not fully capture the “assignment mechanism” behind highway construction (Rubin, 1991). Though the Bureau of Public Roads (later, the Federal Highway Administration) exercised final statutory authority over highway placement, assignment decisions were a result of an interplay of state highway departments and federal authorities. While these deliberations may warrant additional qualitative analysis, they were not sufficiently documented to be useful in a statistical analysis.

2.2 Results

The regression results demonstrate that suburban counties with more highways became less Democratic than they would have been otherwise. The estimates on the overall sample suggest modest effects, though predicted values simulated from a model interacting the treatment and the South dummy variable suggest substantial regional heterogeneity in effects, with most of highways’ effects taking place in Southern states.

Sachuest Turnpike was built in the 1930s and was later incorporated into the Interstate system. Such toll roads did not draw down the generous benefits given to other Interstate highways and would not have been expected to benefit from the Interstate Highway Act.
The bootstrapped, lowess-smoothed estimates for each election year from 1960 to 2008 appear in the top panel of Figure 3. In the full (unmatched) sample, the presence of an Interstate highway in a county reduced the Democratic presidential vote by between 1 and 2 points over a 24-year period from 1976 to 2000. These effects appear to have declined in subsequent elections, possibly as neighborhoods on the metropolitan periphery welcomed later, more diverse generations of residents. However, highways’ effect on partisanship in Southern counties has been remarkably stable over time. Between 1976 and 2004, the presence of an Interstate highway in a Southern county reduced the Democratic presidential vote by 2.5 to 3 percentage points relative to a comparable non-highway county. In non-Southern counties, the largest effect estimated was during the mid-1980s and was approximately one point, but highways’ effects were not detectable outside this period.

Estimating the same regression models on the matched sample validates the estimates obtained without matching (Figure 4), yielding larger effect sizes in the national sample driven primarily by larger effect sizes in the Southern states. In the full national sample, effect sizes between the mid 1970s and mid 1990s were about two percentage points, declining to zero by the 2000s. In the matched sample, Interstate highways made suburban counties in the South 4 to 5 points less Democratic than they would have been in the absence of freeways between the years 1972 to 1996, dropping to 3 points by 2008. As in the unmatched sample, states outside the South yield mixed results. Evidence of an early negative effect on the Democratic vote share gives way to a highway-induced pro-Democratic effect by the 2008 election. Though this effect runs opposite the expected direction, it is imprecisely estimated.

These two sets of findings suggest that much of highways’ effect on the suburban partisan vote has come in the South. Of the effects observed in the county-level analysis, the large effect sizes in the South are most easily explained by the Southern politics literature. A possible reason for regional effect heterogeneity is that earlier construction of freeways and in non-Southern areas, especially in
Figure 3: Lowess-smoothed OLS estimates of the effect of construction of a Interstate highway in a county by year \( t - 4 \) on the difference in the Democratic presidential vote between 1952 and year \( t \). 80% (dashed line) and 95% (solid line) confidence intervals accompany each estimate. Unsmoothed estimates appear as points.
Figure 4: Lowess-smoothed OLS estimates of the effect of construction of a Interstate highway in a county by year $t-4$ on the difference in the Democratic presidential vote between 1952 and year $t$, using the CEM-matched sample and excluding early-adopter states. 80% (dashed line) and 95% (solid line) confidence intervals accompany each estimate. Unsmoothed estimates appear as points.
the Northeast, produced residential segregation at an earlier stage than in the Southern sample, so that suburban areas in the fixed catchment area defined for the study began their life cycles decades before comparable neighborhoods comparably geographically situated in the South. The earlier construction of infrastructure and the more extensive settlement of counties in the suburban catchment area before passage of the Interstate Highway Act may explain the relatively smaller effects observed in the study period. Moreover, the postwar development of the South depended more substantially on highways and other forms of federal investment (Schulman, 1994). As highways connected a poor rural labor force to the outside labor market, Interstate highway crossroads became suburban and exurban boomtowns (Schulman, 1994, 116) that supported the Republican Party. The overall poverty of rural areas and low land costs made these areas affordable targets for new residential development. Simultaneously, highways provided white Southerners with easier use of the exit option to circumvent desegregation efforts: white flight in the South fed more rapid growth of suburban Republicanism in these areas, as white voters fled urban school districts and cities when the federal government intervened on voting rights and segregation policy (Kruse, 2005; Lassiter, 2006). The substantial realignment of the Solid South and large swings in partisan allegiance during this period may have accelerated highways’ effects, as changes in residential patterns induced by highways coincided with changing partisanship.

2.3 Mechanisms

Isolating the mechanisms underlying any causal effects is typically difficult and demands strong assumptions (Imai et al., 2011). In the case of the county vote, highways may be sorting ex ante Democratic and Republican identifiers, or placing them in contexts in which they are more likely to vote for one party over the other. With a range of caveats, causal mediation analysis may permit us to deal with these questions. However, just by observing highways’ effects on variables related to partisanship, we can find
evidence that suggests plausible mechanisms.

Causal effects observed in suburban counties may have occurred through compositional change (migration of Republicans and cohort replacement) or conversion of Democrats in place. Gallup and Roper survey data from the period of highway construction suggests the former may have occurred holding income constant, urban Republicans in the 1970s and 1980s were between 12 and 18 points more likely than urban Democrats to express a preference for suburban residence (Roper Organization, 1976; Gallup, 1983), even after controlling for income. However, this result captures only public attitudes, not behavior; individuals were asked to describe their ideal residential setting without accounting for income constraints.

County-level Census data provides more evidence about about the changes in composition that accompanied partisan change, even if these results do not capture behavioral microfoundations. I examine highways’ effect on five correlates of partisan voting behavior, using the same models used to estimate highways’ effect on the Democratic vote. The outcome in each case is the measured outcome at each Census between 1970 and 2000. The analysis is performed on the matched sample. Four of the included variables are socioeconomic correlates of partisanship: Average home value (2010 dollars), Per capita income (2010 dollars), Percentage of workers over 16 working outside the county (a measure of a county’s commuter status), and the Percentage of homes built in the previous decade. Finally, to test for highways’ effect on racial compositional change, I estimate the effect on the Nonwhite percentage of the population.

These findings (Figure 5) suggest that an explanation of the partisan differences in across suburban counties may stem from highway-induced changes in counties’ economic composition. Specifically, across the previous four Censuses, 1970-2000, counties with Interstate highways have become higher income, have observed higher home values, and have a higher out-of-county commuter rate than com-
Figure 5: Interstate highways’ impact on economic and racial correlates of partisanship in suburban counties (average treatment effect on the treated using dichotomized treatment variable).

parable counties without Interstate highways. These results are consistent with the model of residential sorting laid out earlier: highways enable creation of new, upper-middle-class and wealthy suburbs in rural areas. The results offer little evidence that highways have brought about differences in racial composition between suburban counties, though this is unsurprising given the homogeneously white population in the chosen sample. (We would expect to see a clearer effect on race when examining the urban-suburban divide.)

3 Highways’ and Urban-Suburban Geographic Polarization

A second, related analysis aims to capture highways’ impact on the partisan split between the urban and suburban portions of metropolitan areas. While the previous section demonstrated that Interstate high-
ways make suburban counties less Democratic, these analyses demonstrate that an increase in highway density across a metropolitan area facilitated partisan sorting between the city center and the periphery of the metropolitan area. Adopting an original metric of highways’ spatial impact on a metropolitan region—Interstate exit density—I show that metropolitan areas with Interstate exit density above the median became more polarized by almost four points relative to comparable metropolitan areas with highway exit density below the median.

3.1 Data and Methods

To assess changes in urban-suburban partisan sorting, I construct a unit of analysis called the urban-suburban dyad. This unit consists of the central (i.e., urban) county (or counties) in the metropolitan areas around the Top 100 U.S. cities as of 1950, and suburban counties defined by a distance-based rule. Urban counties are defined as those encompassing the central city (or cities), while suburban counties are those that do not contain a major city but whose centroids fall within 80 kilometers of the central city (or cities). Small cities that fall within the catchment area of a larger metropolitan area are merged into the larger metropolitan area, effectively constructing multicentric metropolitan areas.) After these cities are combined into single metropolitan areas, the resulting sample contains 73 urban-suburban dyads. Summary statistics for these variables appear in Table 2.

Outcome: Urban-suburban polarization is defined throughout these analyses in means suitable for difference-in-difference analysis, as the difference election year \( t \) and 1952 in the urban-suburban gap in the Democratic presidential vote. Let \( \bar{D}_{ist} \) represent the Democratic presidential vote share in suburban counties in metro area \( i \) in year \( t \), and \( \bar{D}_{iut} \) represent the Democratic presidential vote share in the urban counties in metropolitan area \( i \) in year \( t \). The outcome of interest is then:

\[
\Delta_{i,t} = (\bar{D}_{iut} - \bar{D}_{iu,1952}) - (\bar{D}_{ist} - \bar{D}_{is,1952})
\]
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1956</td>
<td>0.005</td>
<td>0.008</td>
<td>0</td>
<td>0.050</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1964</td>
<td>0.023</td>
<td>0.027</td>
<td>0</td>
<td>0.155</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1968</td>
<td>0.032</td>
<td>0.033</td>
<td>0</td>
<td>0.162</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1972</td>
<td>0.038</td>
<td>0.038</td>
<td>0</td>
<td>0.197</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1976</td>
<td>0.041</td>
<td>0.040</td>
<td>0.004</td>
<td>0.214</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1980</td>
<td>0.044</td>
<td>0.042</td>
<td>0.004</td>
<td>0.214</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1984</td>
<td>0.045</td>
<td>0.042</td>
<td>0.004</td>
<td>0.214</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1988</td>
<td>0.046</td>
<td>0.042</td>
<td>0.004</td>
<td>0.217</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1992</td>
<td>0.047</td>
<td>0.043</td>
<td>0.006</td>
<td>0.220</td>
</tr>
<tr>
<td>Exits Open Per Square Mile, 1996</td>
<td>0.049</td>
<td>0.043</td>
<td>0.006</td>
<td>0.220</td>
</tr>
<tr>
<td><strong>Covariates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban-Suburban Diff. in Dem. Pres. Vote, 1948</td>
<td>0.034</td>
<td>0.086</td>
<td>-0.201</td>
<td>0.210</td>
</tr>
<tr>
<td>Urban-Suburban Diff. in Dem. Pres. Vote, 1952</td>
<td>0.033</td>
<td>0.093</td>
<td>-0.169</td>
<td>0.197</td>
</tr>
<tr>
<td>Urban-Suburban Diff. in Dem. Pres. Vote, 1956</td>
<td>0.024</td>
<td>0.092</td>
<td>-0.202</td>
<td>0.226</td>
</tr>
<tr>
<td>Urban-Suburban Diff. in Proportion Nonwhite, 1950</td>
<td>0.026</td>
<td>0.056</td>
<td>-0.132</td>
<td>0.185</td>
</tr>
<tr>
<td>Urban-Suburban Mean, Proportion Nonwhite, 1950</td>
<td>0.098</td>
<td>0.112</td>
<td>0.003</td>
<td>0.440</td>
</tr>
<tr>
<td>Log Persons/Sq. Mi., 1950</td>
<td>5.10</td>
<td>0.93</td>
<td>3.74</td>
<td>8.013</td>
</tr>
<tr>
<td>South</td>
<td>0.275</td>
<td>0.449</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Summary statistics for treatment variables and covariates used to construct urban-suburban dyads (n=80).
As in the suburban-county analysis, this approach permits unbiased estimation of treatment effects provided the potential differences over time are identical conditional on the included covariates. A plot summarizing the change in this quantity between the years 1952 and 2008 appears in the Online Appendix, Figure A-12.

Treatment: An original measure of highways’ spatial influence, the *Interstate highway exits per square mile* of land area in each metropolitan area, captures the extent to which the area is not just traversed by Interstate highways, but also connected to and dependent on them for transportation within the metropolitan area. Extending the widely used cardiovascular metaphor applied to highway systems (e.g., “arterial roads”), a greater number of exits suggests that highways are used not only as a conduit of long-range traffic, but as connections to minor arteries, which in turn connect to the local street network “capillaries.” Data on exit locations are drawn from the 2008 StreetMapUSA exits layer (ESRI, 2008). To create a panel data set capturing exit construction, a cartographic shapefile containing contemporary exits was merged with the Federal Highway Administration PR-511 master file, a chronological record of the start and completion dates of local segments of the Interstate system. To establish the opening date for each exit, these geocoded points were linked to a GIS shapefile containing all exits on the Interstate System as of 2008, producing a database of actual exit locations and their implied year of construction. (While some exits have been added to Interstates after initial construction, fixing the number of exits along Interstates was a key goal of highway engineers hoping to minimize cross-traffic; subsequent changes would have been endogenous to these choices.) The count of exits is then divided by the total land area within the urban-suburban dyad. The resulting variable captures Interstate highways’ overall

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10Separate analyses based on a preferred metric that appears in the urban economics literature, the number of “rays,” or radial highways, emanating from a metropolitan area (Baum-Snow, 2007), appear in the Online Appendix.
spatial presence in each metro area each year between 1956 and 1996, taking into account the physical geography of the area. This variable is coded to accommodate several functional form assumptions, including linear, log-transformed, and dichotomized versions. This treatment variable is displayed in the context of a typical urban-suburban dyad, the Atlanta metro area (Figure 6). An 80-kilometer buffer centered on the city of Atlanta delimits the scope of the metropolitan area and the land area used to calculate Interstate density. Interstate highway exits used to construct the highway density measure appear as points.

Covariates: A common set of covariates obtained from Census and electoral data are used to model exits’ impact on partisan voting outcomes. Key variables are coded in two ways: the urban minus suburban (within-dyad) difference and the unweighted mean of the urban and suburban averages within each dyad. Electoral variables include the *Lagged urban Democratic presidential vote share minus the suburban Democratic presidential vote share* for 1948, 1952, and 1956. These variables predict much of the subsequent impact of the regional partisan realignment in county voting patterns. Census variables include both the *Urban percentage non-white minus the suburban percentage non-white* and the *Unweighted mean of urban and suburban percentage non-white*. These aim to capture the potential role of racial heterogeneity as a contributor to white flight and residential sorting. An indicator variable for cities in the *South* captures differences in the pace of freeway construction in that region: older, mostly non-Southern cities were more likely to build turnpikes and urban freeways before the passage of the Interstate Highway Act, and voting behavior and voting rights across the region different from the rest of the country during the first few decades of the 1952-2008 study period. *Log population density* correlates with two important variables: the metropolitan Democratic presidential vote highway density.

11I examine presidential election results through 2008, but the PR-511 data (and thus, the exit data) are updated through 1996, by which point the Interstate Highway System was substantially complete.
Figure 6: Map of the Atlanta metro area, illustrating exit density, as well as the geographic radius adopted when constructing urban-suburban dyads.

*Estimation:* Multiple estimation methods are used to establish robust results. Least-squares regression is used to estimate the growth in polarization in each metro area after 1952 as a linear function of
exit density. Setting $\Delta_t$ as the vector of $\Delta_{i,t}$ values (the difference in the urban-suburban gap in the Democratic presidential vote in dyad $i$ between year $t$ and 1952), the causal effect of the treatment variable $z_t$ (exit density or log exit density at election year $t$), $\beta_{z_t}$, is estimated along with other parameters according to the following linear model:

$$
\Delta_t = \beta_0 + \beta_{z_t} z_t + \beta_2 x_1 + \ldots + \beta_k x_k + \epsilon
$$

(3)

where $\beta_{z_t}$ represents the causal effect of a one exit-per-square-mile increase in exit density, $\Delta_t$ is the difference in between 1952 and year $t$ in the urban-suburban difference in the Democratic proportion of the presidential vote, and $x_1, \ldots, x_k$ represent the included covariates.

A second analysis dichotomizes the treatment variable around the sample median, then generates matched samples of treated and untreated units to estimate the effect of highway construction. Urban-suburban dyads were considered “treated” if the density of exits or the number of rays was above the median.\(^{12}\) Using genetic matching\(^{12}\) ([Diamond and Sekhon, 2005]), I create a matched sample of treated and similar untreated units. This method generally yields better improvements in observed balance in small samples than other, propensity-score based matching methods, with the cost of introducing additional imbalance on some variables.\(^{13}\) The genetic matching algorithm employs the same set of covariates that appear in the linear regression models. Those models are subsequently applied to the matched sample to account for remaining imbalance between treated and untreated units and to estimate the causal effect of the dichotomized variable on the population represented by the treated units. Following the procedure...\(^{12}\) Dichotomizing the treatment variable introduces an assumption that the “dose” of the treatment of interest is identical for units above the median and for units below the median.\(^{13}\) All matching methods that assume that data are multivariate $t$- or normal-distributed face this problem. When sufficient observations are available, variants of exact matching are preferable, as they are not vulnerable to this assumption.\(^{12\text{a}}\)
adopted in the previous section, I estimate $\beta_{zt}$ on the matched and unmatched samples and smooth the estimates by the same lowess-based method used in the suburban county analysis.

### 3.2 Results

The first set of results the effect of the number of exits per square mile in each metropolitan area under simple linear model and the log-transformed variable. A model using a log-transformed version of exits per square mile indicates a large effect of Interstate highway construction. Estimates are presented as the first difference associated with a shift between the 25th and 75th percentile of highway density in each year. Highways’ effect on the urban-suburban gap in the Democratic presidential vote increases nearly monotonically across the study period, reaching a peak of 4 points in the 1990s, with 95% confidence intervals corresponding to statistical significance at the $\alpha = 5\%$ significance level (Figure 7, right panel). The null of no effect can be rejected at standard significance levels through the 2008 election. The non-logged version of the exits-per-square-mile variable also yields positive estimates, but constructed 80% confidence intervals permit rejection of the null of zero effect only between 1972 and 1996 (Figure 7).

A third approach to this modeling matches “treated” observations (those with a highway exit density greater than the sample median) to “untreated” observations and reaches substantively similar estimates. For almost all covariates in most years, matching reduced the standardized imbalance between treatment and control to below 0.5 standard deviations of the control-group values in the pre-matched population. Applying a linear regression model to reduce the consequences of the remaining imbalance (accepting remaining model dependence) yields estimates of the average treatment effect on the treated (ATT) substantively comparable to those obtained in previous analyses. The average difference in polarization

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14 The interquartile range of the number of exits per square mile was [0.003, 0.1] in 1960, rising to [0.19, 0.56] in 1996.
Figure 7: Simulated estimate of the first difference in urban-suburban party polarization, comparing across the interquartile range of exits per square mile in each year, using the untransformed (left panel) and log-transformed versions of the variable. Bootstrapped 80% and 95% confidence intervals accompany the point estimates.

between treated units and comparable untreated units is about two percentage points (Figure 8).

3.3 Robustness Checks

Multiple robustness checks were applied to these analyses and appear in the Online Appendix.

Supplemental analyses apply an instrumental variables approach, using two-stage least squares to estimate the effects of the number of rays (or radial highways emanating from the central business district) instrumented by the number highways that appear on a 1947 planning map (Baum-Snow, 2007). Urban and regional economists have adopted variations on this instrument to address their concern that highway construction in early years may beget other highways, compromising the exogeneity of the treatment of interest. In addition to rays, researchers have used planned highway locations (Michaels, 2008) and even
Figure 8: Effect of highways on the urban-suburban Democratic presidential vote gap, estimated by least squares regression on the matched sample. The estimate captures the difference in the urban-suburban Democratic presidential vote difference, shifting the number of built exits from below the median in year $t$ to above the median. Bootstrapped 95% (solid line) and 80% (dashed line) confidence envelopes are generated from the lowess-smoothed curves to incorporate information from proximate observations.

Varying the outer radius used to define each metro area’s suburban catchment area does little to change either the point estimates or uncertainty estimates. Defining the suburban hinterland to include observations with centroids as much as 100 kilometers (62 miles) from the city center yields more precise estimates of the effect of highway exit density under both the linear and log functional form assumptions.
Reducing the metropolitan area’s outer radius from 80 kilometers to 60 kilometers yields estimates that remain statistically significant across most of the post-treatment study period, diminishing substantially in magnitude only once the outer radius drops to 40 kilometers. (These additional analyses appear in the Online Appendix.) The positive relationship between outer radius and highways’ polarization effect is consistent with the stated hypothesis that highways add to polarization by stimulating growth in lower-density, more remote “exurban” or rural sections of cities’ hinterlands (McKee 2008).

3.4 Mechanisms

While these analysis have been concerned with estimating highways’ impact on the urban-suburban gap in the Democratic vote share, it is equally important to ascertain whether highways facilitate this split by concentrating Democrats in cities, decreasing the Democratic share of the suburbs, or some combination of the two. If highways induce localized Republican growth in the suburbs, we would expect to observe suburban portions of metropolitan regions with more highways to become more Republican than comparable suburban portions of other regions. To consider these differences, I estimate the difference in the Democratic vote share between year \( t \) and 1952 separately for the urban and suburban components of each dyad.

This analysis suggests that highways influence on the two-party vote occurs through its effect on suburban areas. Figure 9 displays the relevant lowess-smoothed estimates. The left panel displays the effect within the urban portions. These estimates provide little evidence that highways affect the urban Democratic vote share. The right panel, however, suggests that highways stimulated the Republican ascent of suburbs. Over the period 1960-1984, the suburban portions of metropolitan areas with exit density above the median became more Republican than comparable areas in the bottom half of the distribution. This effect reached a peak of four points in 1984, remaining relatively stable, albeit with
larger standard errors, since then.

Figure 9: Lowess-smoothed estimate of the first-difference in urban-suburban polarization in the Democratic vote share, generated using coefficients from least squares regression model applied to the matched data. Interstate highway exit density on the Democratic vote share in the urban (left) and suburban (right) portions of the constructed urban-suburban dyads. Bootstrapped 95% confidence intervals accompany the point estimates.

One may speculate about the degree to which urban-suburban partisan polarization is tied to correlates of partisanship that are similarly geographically polarized. While highways’ effect on these correlates was previously estimated in the suburban county sample, the same compositional variables may operate differently across the urban-suburban divide. Following the same strategy adopted for the county-level sample, the urban-suburban difference in key Census outcomes, including Per capita income, Percentage of homes built in the last decade, Average home value, Percentage nonwhite, and Per-

\footnote{These estimates represent average effects in each group estimated separately, so addition of these two estimates will not equal the total average effect on urban-suburban polarization.}
percentage working outside the county are substituted for the presidential election outcomes, and estimates generated for each Census, 1970-2000.

Lowess-smoothed point estimates for these urban-suburban differences are presented in Figure [10]. Estimated on a smaller sample, each of these estimates has a fair deal of uncertainty, but the estimates provide evidence of highway-induced urban-suburban sorting founded on both economic and racial shifts. Foremost, metropolitan areas with highway density above the sample median are more polarized with respect to housing age. Starting in 1980, the urban-suburban gap in the proportion of homes built in the last decade was between 2 and 4 points higher, on average, in areas with highway exit density above the median than in comparable areas with exit density below the median. The urban-suburban gap in the proportion of out-of-county commuters has been between two and four points larger in metro areas with high highway density than in comparable counties with lower highway density. With some uncertainty, metropolitan areas with more highways became about two to four points more polarized than comparable cities with fewer highways. However, Interstate highways do not appear to have had a discernable impact on the urban-suburban income.

4 Discussion

The findings here confirm multiple empirical implications of a model of partisan geographic sorting that accounts for the role of transportation policy. Across a national sample, highways reduced the Democratic vote by about two points in the counties where they were built, and these effects were pronounced in the South, where highways were responsible for an increase in the Democratic vote exceeding 4 points. Subsequent analyses of the urban-suburban gap suggest a link between these results and urban-suburban polarization. Metro areas with greater Interstate highway density (at the 75th percentile) observed up to 3 to 4 points more urban-suburban polarization in the Democratic presidential vote than comparable
Figure 10: Interstate highway exit density and urban-suburban polarization of selected correlates of partisanship. (Average treatment effect on the treated). Treatment variable is highway exits per square mile four years before each Census year, dichotomized at the sample median in each treatment year. Metropolitan areas with highway density at the 25th percentile. These findings do not appear to be model dependent and are confirmed by rerunning the analysis after matched sampling [Ho et al. 2007].

This study links public policies that shape space to ultimate geographic outcomes. Unfortunately, limited data are available to capture the how highways influenced the dynamics of individual residential choice after the construction of Interstate highways. While individual-level data provide some guidance on individual preferences, and local area studies commonly asked about residential preference during this period, such studies rarely provided sufficient data on respondents’ location and subsequent behavior to permit an analysis linked to these studies. Results from county-level Census analyses and reference to limited national survey data suggest that highways catalyzed an individual-level sorting process around
a mix of partisan, economic, and racial concerns.

Among other limitations of this study, one might challenge the assumption that the Interstate Highway System can be interpreted as an exogenous treatment after accounting for other predictors of highway location and suburban political development. In particular, skeptics may point to various types of political meddling in highway planning as a source of omitted variable bias. In practice, the block-by-block routing of Interstate highways was the result of negotiations between the federal Bureau of Public Roads (later, the Federal Highway Administration), state highway departments, and local politicians. However, local governments and their organizations had no formal role in highway planning until recently. While the Federal-Aid Highway Act of 1962 required state governments to provide comprehensive planning in the building of freeways, regional planning organizations’ involvement in highway construction decisions was *pro forma* until the Federal-Aid Highway Act of 1973 granted regional authorities a formal role in transportation planning (Gerber and Gibson, 2009). Most of the Interstate highways accounted for in this study were also built before the 1970s freeway revolts, when local citizens successfully challenged a number of urban transportation projects.

Another reasonable concern is that Congress has customarily meddled in transportation planning, and that the models presented here fail to account for this interference. This concern may apply to particular elements of the federal highway program in which members of Congress target Highway Trust Fund dollars to demonstration projects (Lee, 2003; Evans, 1994), continuing the American tradition of Congressional micro-management of “collections-small” projects (Weingast and Wallis, 2005). However, under the Interstate program Congress delegated to the BPR substantial control over the Interstate designation process, and until the late 1970s did little to micromanage, or give states latitude to deviate from, the original Interstate plans. Parochial constituencies could exercise influence over small changes in highway routing and construction, but this pressure was often placed on the state highway
departments, not on Congress. To the extent that highways were built in response to political demands, such decisions were made through modification of the existing Interstate map, not through Congressional earmarks (Mertz and Ritter [2010] 78). Indeed, the Bureau of Public Roads archives are replete with Congressional correspondence asking for designation of additional highways as Interstate routes, responses from the Bureau of Public Roads indicating that such modifications would require additional general purpose legislation.\footnote{See, e.g., Charles D. Curtiss to Thomas H. Kuchel, 5 October 1956, National Archives II, Record Group 30, Box 1137, “California: Congressional, Part 1 of 2.”}

Another limitation of this study is its dependence on pre-established geographic units to draw inferences about the inherently subjective urban-suburban relationship. Any study that uses aggregate data will produce findings that are vulnerable to the modifiable areal unit problem (Openshaw and Taylor [1981]). In addition, the adoption of a rule-based definition of metropolitan areas and suburban counties may yield inferences that are vulnerable to coding choices. Gatrell (1983) (10-11) argues that reliance on arbitrary units and rule-based definition of sets can produce unconvincing results. To ameliorate these concerns, the Online Appendix presents results for varying rule-based definitions of urban and suburban counties.

Finally, a key limitation of this data set is that it relies on a database of Interstate highways and does not incorporate additional information about non-Interstate highways. One reason to rely on this dataset is that the Interstate highway map, while not assigned randomly to counties, was at least planned ex ante with a set of fixed criteria in mind. Another reason is that Interstate highways are the highest volume freeways, and planning of feeder roads and other minor highways is at least partially endogenous to existing Interstates. Other federally subsidized highway projects were not subject to the same national planning process. Where U.S. and state highways were built to connect with Interstate highways, any
associated effect on local partisanship can be interpreted as a post-treatment consequence of the Interstate treatment. Nevertheless, the Online Appendix (Section B) reports results from a study based on the number of “rays,” or radial highways, emanating from major metropolitan areas (Baum-Snow, 2007).

5 Conclusion

Public policies that shape geographic space can change politics. This article has considered a subset of such policies—transportation networks—and how they change the political composition of communities. Transportation networks can act as a catalyst for partisan sorting in the presence of partisan homophily and localized discrimination. Differences in the type of transportation system provided can also facilitate sorting as different transportation modes serve different constituencies. While transportation location often is discussed in terms of relatively frictionless agent-based models, highway-induced changes in the spatial distribution of Democrats and Republicans are not momentary changes; transportation networks indirectly subsidize the construction of new physical communities. In the case of the Interstate Highway System, highways facilitated the growth of new suburban communities that either were or became more Republican.

These results also suggest that substantial latitude exists to expand studies of public policies’ effects to incorporate political geography. Until now, the study of public policies and their effects has most focused on policies’ impact of individual-level behavior (Campbell, 2003; Soss, 2000; Mettler, 2002) as a function of individual-level exposure to social welfare programs, but these studies have rarely taken into account how public policies change political behavior by shaping individuals’ geographic context (Enos, 2010; Gay, 2008). Such studies have rarely engaged how place-making policies (Glaeser and Gottlieb, 2008) shape the American political map. While numerous other long-term factors, including the geographic persistence of ethnic voting patterns (Gimpel and Cho, 2004) explain American partisans’
spatial distribution, the findings here point clearly to public policy’s central role in these changes.

The Interstate Highway System’s effects on both local and metro-level political geography call into question studies that explain metropolitan development in terms of agent-based models of individual behavior in which macro-level outcomes arise from individuals selecting across neighborhoods, municipalities, and metropolitan areas. To previous findings on local governments’ limited control over the factors that attract residents and businesses (Peterson, 1981), we can add that local governments may be at the mercy of infrastructure programs implemented by the federal and state governments. Even in those areas in which municipalities have residential gatekeeping power—zoning, policing, and other housing regulations—their ability to control the influx of new residents is often at the mercy of transportation policies dictated from above. Thus, these findings confirm the limitations of the Tiebout and Schelling sorting models in the face of public policies that shape residential mobility.\footnote{17}

Metropolitan regions with higher levels of geographic polarization are that way not only because of individual sorting decisions, but because of the intervention of public policy. To be sure, the deindustrialization of American cities, the suburbanization of industry, urban renewal, racial segregation, the relative quality of suburban and rural school districts, and a plethora of other factors contributed to growth of the Republican vote in suburban areas. As surely as these changes reshaped metropolitan areas, however, highways acted as a catalyst, enabling residents to select into communities consistent with their residential preferences. Policies primarily intended to bring Americans closer together instead had the unintended effect of allowing them to live apart. An unintended consequence for the American politics was the creation of new suburban Republican enclaves and a larger partisan split between major cities and their hinterlands.

\footnote{17For an earlier geography-focused critiques of the model, see Buchanan and Goetz (1972) and Hamilton (1975).}
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and Not the National Government Financed Highway Construction in the Antebellum Era.”


Online Appendix

A County-Level Analysis

A.1 Suburban-County Sample

A.1.1 Defining the Suburban County Sample

This section addresses one of the basic concerns that arises in the study of American metropolitan areas: the potential sensitivity of findings to rule-based sample definitions. The results presented in the body of the paper define suburban counties by including only counties more than 20 kilometers from the central city and less than 100 kilometers from the central city. Here, I demonstrate that these findings are robust to both selection of the inner and outer radius and to a sampling frame based on population density. I also show that the results are robust to the population cap used for suburban counties.

First, I demonstrate the robustness of the findings to selection of inner and outer radii. Results for the full suburban county sample, excluding pre-1956 freeway adopters and applying coarsened exact matching, appear in Figures A-1 and A-2. To begin, the full sample, excluding early-adopter states, is subsampled using a grid-search procedure. This grid search covers three different values of the inner radius (10, 20, and 30 kilometers) and six values of outer radius (40, 50, 60, 70, 80, 90, and 100 kilometers). This yields a total of 21 different subsamples. On each of these samples, coarsened exact matching and least squares regression are used to estimate the average treatment effect of highways on the suburban county vote, following the procedure described in the text. For all samples with an outer radius greater than 50 kilometers, the results corroborate those presented in the main text.

Figure A-3 displays a similar grid search over sample definition rules. Instead of defining the sub-
urban sample for each metropolitan county in terms of defines the sample in terms of county population density. Each sample is defined by selecting different minimum and maximum county population densities, defined in terms of sample quantiles. This grid search applies the same matched sampling and regression methods to samples defined by shrinking the density window progressively. Samples that include more low-population-density counties yield results closer to those obtained. The findings are not robust to including only counties near median population density.

Finally, Figure A-4 displays the consequences of changing the maximum county population (from the 1950 Census) permitted in the suburban county sample. This population cap removes from the sample large counties that are outside the central city of a metropolitan area but may nevertheless be heavily urbanized. Varying the maximum permissible population from 100,000 to 600,000 has no meaningful bearing on the results.

A.2 Matching Balance

A.2.1 Varying Treatment Definitions

*Non-Time-Dependent Treatment:* As a robustness check, I redefine the treatment variable to indicate whether an Interstate highway was built in the county at any point through the study period. This step essentially coarsens the treatment variable to ignore the year in which treatment occurred, a step justified by the relatively short build-out period of the Interstate Highway System. Among the 1,327 counties in which an Interstate highway was built, 79 percent experienced treatment between 1956 and 1972. In only five percent of counties did states build freeways before passage of the Federal-Aid Highway Act of 1956—mostly Northeastern states that built toll-funded turnpikes that were later “grandfathered” into the Interstate Highway System. The coefficient estimate for election years 1960 to the present estimates the treatment effect associated with this coarsened treatment variable. The results (Figure A-5) largely
coincide with the findings obtained using the time-varying treatment. On average, if highways had not been constructed in the suburban counties in the full sample, those counties would have been about 1 to 2 points more Democratic during a period ranging from 1968 to the early 2000s. In Southern states, Interstate highways made suburban counties 2.5 to 3 percentage points less Democratic. They had a small effect on suburban counties outside the South only distinguishable from zero during a brief period in the 1980s. The absence of statistically significant effects during the pre-treatment period, especially provides support for the unbiasedness of the findings.
A.2.2 Coarsened Exact Matching

A.3 Improved Measures of Latent County-Level Partisanship

Levendusky, Pope and Jackman (2008), which develops new Bayesian methods for estimating latent partisanship, find that the presidential vote is an appropriate proxy for the presidential vote. They note that their pattern of results should “provide reassurance to researchers who have used district-level presidential vote as a proxy for district-level partisanship” (Levendusky, Pope and Jackman 2008, 750). The discussion in Levendusky, Pope and Jackman (2008) also suggests that a large proportion of the difference between the two measures can be attributed to home-state “favorite son” effects. To demonstrate robustness to this aspect of presidential returns, one of the robustness checks presented here includes two dummy variables: one for home-state Democrats, the other for home-state Republicans. Including these variables does not meaningfully shift the estimates derived from either the full sample (Figure A-7) or on the sample excluding early-adopter states (Figure A-8).

A.4 Accounting for Uniform Swings

The outcome is also recoded to account for year-to-year national changes in elections. The outcome variable is defined by subtracting the national Democratic presidential vote from the county level vote in each election year. This step allows slightly more direct comparability of the presidential election results across elections.

The results derived from this approach vary slightly from those that appear in the body of the paper. On the full sample, the smoothed estimates of the ATT on the county-level Democratic vote (after accounting for national swings) rise to 1.5 percentage points, holding steady through the 2008 election (Figure A-9). An analysis excluding early adopter units yields slightly smaller, and sometimes impre-
cise, estimates, reaching 1 percentage point. Several of these smoothed estimates fail to reach statistical significance at the customary 95% confidence level (Figure A-10).

A.5 Urban Riots

The construction of highways through predominantly black neighborhoods was a major urban grievance (among many others) that motivated urban unrest. As such, it is one of many causal pathways by which highways may have contributed to the developments presented here. At the same time, many urban disturbances may have developed in response to a broad array of other grievances and due to varying local demographics. Thus, accounting for the occurrence of disturbances may anticipate one instance of omitted variable bias not anticipated. For each metropolitan area in the dataset, a “riots” dummy variable was coded with the number of years in the 1961-1968 period for which Spilerman (1973) reported a disturbance. These results, applied to the full sample (with matching and excluding early-adopter states), appear in Figure A-11.

B Polarization Analysis

B.1 Defining Urban-Suburban Dyads

To account for large metropolitan areas in which a top-100 city falls within the suburban zone of another major city (e.g., Jersey City and New York; Dallas and Fort Worth), such paired cities were merged into a single large metropolitan area, and their suburban catchment areas combined into a single larger catchment area. For cases in which a smaller central city was clearly subordinate to a larger city (e.g., New York and Jersey City), the county containing the smaller central city was redefined as “suburban.” However, in the case of clear multi-city metropolises such as Dallas-Fort Worth and Minneapolis-St. Paul, each of the counties containing the central cities were classified as “urban” and their data aggregated.
B.2 Limitations of Precinct-Level Data

I explored the use of municipal-level election returns, which would have provided finer spatial resolution. This included calculations based on data from the Record of American Democracy (ROAD) project (King and Palmquist, 1998), which provides solid precinct-level coverage at least for the country’s northeastern quadrant. However, many states do not retain election records below the county level, and in other cases historical Census data to match electoral geography are not readily available. The absence of pre-treatment Census data at low aggregation levels (Fitch and Ruggles, 2003) prevents the inclusion of suitable covariates in model-based analyses, making causal analysis considerably more difficult. Spatial mismatches between the ROAD data and Census data similarly required substantial missing data imputation, adding noise to included covariates and potentially biasing point estimates (7). Recent systematic projects to collect precinct-level data can do little to solve this historical data mismatch problem. With these limitations in mind, the analysis presented here is limited to county-level data.

B.3 The Secular Change in Urban-Suburban Polarization

A plot of $\Delta_{i,2008}$, the change in the urban-suburban difference in the Democratic presidential vote between 1952 and year $t$, appears in Figure A-12. Taking the unweighted average of all metro areas in the sample, this shift was about 10.5 percentage points, but, like the results from the suburban county-level analysis in Chapter ??, the increase in polarization varies by region. While metro areas across the country have become increasingly polarized, the shift has been particularly pronounced in the South, where five major metropolitan areas experienced the largest urban-suburban shift. Memphis (Shelby County) and New Orleans (Orleans Parish), both of which contained large, newly enfranchised Black Democratic populations, underwent the largest absolute increase in urban-suburban polarization, presumably as a result of enfranchisement of and political mobilization of large Black populations under the Voting
Rights Act. Other, fast-growing areas of the New South from Austin to Atlanta similarly became polarized, with their central counties becoming 30 points more Democratic relative to their suburbs than they were in 1952. Across most of the rest of the country, the difference in the growth of the urban Democratic advantage and the growth of the suburban Democratic advantage was at least ten points in most metropolitan areas. Urban-suburban polarization increased almost everywhere, with the few exceptions appearing in large Western counties that encompass entire metropolitan areas (thus introducing error in the measurement of the urban-suburban gap) and a handful of depopulating, deindustrializing, usually smaller metropolitan areas mostly located in the Rust Belt. In the metropolitan areas whose centers became more Republican than their peripheries, the size of the shift was typically not more than 10 points.

**B.4 Matching Quality**

A summary of balance statistics obtained for each year appear in Figure A-13.

**B.5 The Baum-Snow Data**

Baum-Snow (2007) assigned geographic locations to the nearest mile, interpolating between the start and end points of each freeway project segment. When the Bureau of Public Roads and the Federal Highway Administration monitored state governments’ highway construction progress, data on each highway segment were collected and organized on “strip maps,” long sheets displaying an abstract version of the highway segment annotated with information on the construction start and end dates. The segments that appeared on each map were as short as a fraction of a mile near the center of urban areas, permitting a

Remarkably, in the case of Memphis, even the presence of the nearby Mississippi River Black Belt did not prevent a massive increase in urban-suburban polarization in the Memphis area over the past 56 years.
great deal of geographic precision. However, in the most rural areas, these construction areas typically run from one end of a county to another. These maps were stored in a Federal Highway Administration mainframe. While these strip maps remain in the National Archives, the original PR-511 data have been lost or misplaced by the FHWA.

B.6 Radial Highways as Conduits

An alternative to the highway exit density variable is the number of highway rays emanating from a major city, a metric developed in Baum-Snow (2007). A substantial body of transportation research over the last fifty years, almost all of it based on the monocentric urban model (Burgess, 1925), suggests that these additional highways can be expected to increase dispersion of population by reducing travel time to lower-priced land on the periphery of urban areas. As the federal government has subsidized the construction of single-family residences, highways have been an indirect subsidy to households seeking large, detached homes. Highways increase the radius over which urban and suburban workers can feasibly “drive to qualify” for a home mortgage on a large home. Radial highways are among the most likely means for this drive-to-qualify behavior.\(^\text{[19]}\)

Beyond simple economic motivations related to housing stock, such highways also subsidize residents preferring suburbs for their schools, low crime levels,\(^\text{[19]}\) Economists have observed that the income elasticity of demand for suburban real estate is larger than unity, suggesting that suburban housing qualifies as a luxury good. Indeed, Becker (1965) suggests that it is not the home itself, but the perceived benefits of the space associated with it, that operates as a luxury good. As paraphrased in Glaeser, Kahn and Rappaport (2008), “the key condition for the suburbanization of the non-poor to occur is that the elasticity of demand with respect to income is greater than the elasticity of the value of time with respect to income” (7). Highways may subsidize this form of luxury consumption.
and other public goods. Beyond adding to the core-to-periphery sorting process, highways have been known to generate development along radial routes extending out of cities, and the larger the share of the suburban arc occupied by highways, the heavier the commercial and residential development and the greater the possibility of urban-suburban polarization. Thus, after other pre-treatment factors are accounted for, a city like Indianapolis, with its seven rays, would be expected to observe both higher rates of suburban growth and geographic polarization than a city like Wichita, with its two rays.

Results Using Rays as Treatments: Positive estimates of the effect of rays on polarization are obtained, with both OLS and two-stage least squares yielding effects of between 1 and 4 points across most of the study period after passage of the Interstate Highway Act. The causal effect of moving across the interquartile range of the planned rays variable—from two to four rays—appears in Figure A-14. While the OLS estimates do not reach standard levels of statistical significance, the 95% confidence intervals permit rejection of a negative effect any larger than about 0.6 points between 1968 and 1984 (Figure A-14). Point estimates are positive and are close to statistical significance at the 80% confidence level across most of the study period. Applied to the sample of urban-suburban dyads and using planned highway rays as an instrument, 2SLS yields positive point estimates but very large standard errors across most of the later part of the study period, one would not be able to reject the null of no effect (Figure A-16).

Several weaknesses of the rays variable argue for the use of multiple measures, such as the exits variable, for purposes of estimating highways’ political impacts. One respect in which the rays variable may be problematic is that coastal and peninsular cities (e.g., San Francisco) may have fewer rays only because they are peripheral to the overall network and geographically, rays in such an area can subtend only a limited arc. The exit density avoids this problem by dividing the treatment variable by total land area.
B.7 Instrumental Variables Analysis

The instrumental variables regressions presented in this chapter act primarily to bolster findings obtained using OLS estimation and matching, though the technique can require questionable assumptions. Instrumental variables estimation must satisfy both conditional ignorability of the instrument and the rarely plausible exclusion restriction. Moreover, though OLS and 2SLS yield different estimates, they often yield similar substantive conclusions. Baum-Snow (2007) reaches the same substantive conclusions about the direction of freeways’ effect on suburban growth using OLS and 2SLS estimation. Though the estimates are not directly comparable, in both cases the estimated effect was positive and statistically significant. Finally, the substantive assumptions used in instrumental variables estimation are often questionable. For example, the same reports from which highway-plan instruments have been drawn anticipated that highway construction would stimulate suburban growth. If this knowledge had changed behavior among policy makers in areas other than highway construction, or if this map was in any way related to the outcomes of interest by means other than highway construction, then the highway instrument would violate the exclusion restriction, potentially adding bias to causal estimation rather than reducing it, and with no way of assessing the potential direction of the bias.

Baum-Snow (2007) repeats the widely held belief that the Interstate Highway System was designed with military prerogatives in mind, which overstates the Pentagon’s involvement in highway planning. While the military offered input on the location of freeways relative to military bases, its involvement was at most peripheral: though some local highway routes were planned with military imperatives in mind, the facilitation of interstate commerce and easing of urban traffic congestion were the primary guiding principles of highway system planning, and defense officials never adopted an integral role in highway planning.
regression is suitable as another estimation method, but is not inherently less biased than combinations of matching, difference-in-difference, and linear-model-based estimation.

B.8 Varying Outer Radius

I test the robustness of the results to selection of the outer radius of each metropolitan area. The first sensitivity analysis, which varies the outer radius from 40 to 100 kilometers for the matching-based estimates of the effects of exit density, confirms that the results are highly robust to the choice of outer radius (Figure A-17). Varying the urban outer radius for the rays-based analysis yields point estimates that are typically in the correct direction, but are not as robust to the selection of an outer radius. The already marginal OLS results using the rays variable are substantially less robust to the selection of outer radius (Figure A-17).
Figure A-1: Robustness of findings to definition of a suburban county sample based on the inner and outer radius defining rings drawn around the metropolitan central city. Outer radii of 40 to 70 kilometers.
Figure A-2: Robustness of findings to definition of a suburban county sample based on the inner and outer radius defining rings drawn around the metropolitan central city. Outer radii of 80 to 100 kilometers.
Figure A-3: Robustness of findings to definition of suburban county sample by population density.
Figure A-4: Robustness of findings to exclusion of high-population counties with varying cutoffs.
Figure A-5: Lowess-smoothed, bootstrapped OLS estimates of the effect of construction of an Interstate highway in a county on the difference in the Democratic vote between 1952 and year $t$, coding the treatment variable, $Z = 1$ if an Interstate highway was built in the county at any point. From left to right, results apply to all counties, counties in the South, and counties outside the South. 95% (solid line) and 80% (dashed line) confidence envelopes appear around the smoothed point estimates (blue). Non-smoothed, bootstrapped estimates appear as points.
Figure A-6: Standardized imbalance of included covariates (difference in means between the treated and control group, divided by the standard deviation in the original treated group) under CEM using the time-varying version of the Interstate highway treatment variable and coarsened exact matching. Standardized imbalance in the [M]atched and [F]ull (original) sample are presented for the matched sample for each election year, 1960-2008.
<table>
<thead>
<tr>
<th>Year</th>
<th>Avg Effect on Dem Vote (ATT, Matched Sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>−0.05</td>
</tr>
<tr>
<td>1972</td>
<td>−0.04</td>
</tr>
<tr>
<td>1980</td>
<td>−0.03</td>
</tr>
<tr>
<td>1988</td>
<td>−0.02</td>
</tr>
<tr>
<td>1996</td>
<td>−0.01</td>
</tr>
<tr>
<td>2004</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure A-7: Robustness check using Democratic “favorite son” and Republican “favorite son” dummy variables. Lowess-smoothed, bootstrapped OLS estimates of the effect of construction of a Interstate highway in a county by year $t - 4$ on the difference in the Democratic vote between 1952 and year $t$, applied to CEM-matched sample. Results apply to the full suburban county sample. 95% (solid line) and 80% (dashed line) confidence envelopes are generated from lowess smoothing of point estimates. Note that the additional covariate for “favorite son” candidates is included only at the analysis stage, not in the matching procedure.
Figure A-8: Robustness check using Democratic “favorite son” and Republican “favorite son” dummy variables. Lowess-smoothed, bootstrapped OLS estimates of the effect of construction of a Interstate highway in a county by year \( t - 4 \) on the difference in the Democratic vote between 1952 and year \( t \), applied to CEM-matched sample. Results apply to the full suburban county sample, excluding early adopters. 95\% (solid line) and 80\% (dashed line) confidence envelopes are generated from lowess smoothing of point estimates. Note that the additional covariate for “favorite son” candidates is included only at the analysis stage, not in the matching procedure.
Figure A-9: Robustness check recoding an outcome to subtract out the Democratic percentage of the national presidential vote. Lowess-smoothed, bootstrapped OLS estimates of the effect of construction of a Interstate highway in a county by year $t - 4$ on the difference in the Democratic vote between 1952 and year $t$, applied to CEM-matched sample. Results apply to the full suburban county sample. 95% (solid line) and 80% (dashed line) confidence envelopes are generated from lowess smoothing of point estimates. Note that the additional covariates are included only at the analysis stage, not in the matching procedure.
Figure A-10: Robustness check recoding an outcome to subtract out the Democratic percentage of the national presidential vote. Lowess-smoothed, bootstrapped OLS estimates of the effect of construction of a Interstate highway in a county by year $t - 4$ on the difference in the Democratic vote between 1952 and year $t$, applied to CEM-matched sample. Results apply to the full suburban county sample, excluding early adopters. 95% (solid line) and 80% (dashed line) confidence envelopes are generated from lowess smoothing of point estimates. Note that the additional covariates are included at the analysis stage, not in the matching procedure.
Figure A-11: Robustness check including a covariate for the number of years between 1961 and 1968 during which a racial disturbance occurred in a metropolitan area (Spilerman, 1973). Lowess-smoothed, bootstrapped OLS estimates of the effect of construction of a Interstate highway in a county by year $t - 4$ on the difference in the Democratic vote between 1952 and year $t$, applied to CEM-matched sample. Results apply to the full suburban county sample, excluding early adopters. 95% (solid line) and 80% (dashed line) confidence envelopes are generated from lowess smoothing of point estimates.
Figure A-12: Shift in the urban-suburban gap in the Democratic presidential vote in leading metropolitan areas, 1952 to 2008. Dyads are constructed from counties inside an 80 kilometer outer radius.
Figure A-13: Average of standardized imbalance across all covariates for genetic matching, using the dichotomized exit-density treatment variable.
Figure A-14: Causal effect of highways on urban-suburban polarization in the Democratic presidential vote, 1960 to 2008, estimated by least squares regression without matching. The treatment variable is measured using the number of radial highways (“rays”) emanating from each urban center. Bootstrapped 95% (solid line) and 80% (dashed line) confidence envelopes are generated from the lowess-smoothed curves to incorporate information from proximate observations. Unsmoothed bootstrapped estimates appear as points.
Figure A-15: Causal effect of highways on urban-suburban polarization on the matched sample, estimated using OLS. Estimate reflects a shift in the number of built rays from below the median in year $t$ to a number of rays above the median. Bootstrapped 95% (solid line) and 80% (dashed line) confidence envelopes are generated from the lowess-smoothed curves to incorporate information from proximate observations. Unsmoothed bootstrapped estimates appear as points.
Figure A-16: Causal effect of highways on urban-suburban polarization, estimated by least squares regression. Estimate reflects an increase from two to four highway rays (the interquartile range during the final period). Planned highway rays on a 1947 highway map are the instrument, while constructed rays at the nearest Census year constitute the endogenous treatment. Both regression stages include the covariates used in other analyses. Bootstrapped 95% (solid line) and 80% (dashed line) confidence envelopes are generated from the lowess-smoothed curves to incorporate information from proximate observations. Unsmoothed bootstrapped estimates appear as points.
Figure A-17: Sensitivity of urban-suburban polarization results to choice of outer radius for metropolitan area, exit density analysis. The county containing the central city (or cities) is defined as the urban county in each analysis, while the set of suburban counties used to construct each urban-suburban dyad vary with the outer radius. Top row (left to right): 40 and 60 kilometer outer radius. Bottom row (left to right): 80 and 100 kilometer outer radius.
Figure A-18: Sensitivity of results to choice of outer radius for metropolitan area, analysis using rays.

The county containing the central city (or cities) is defined as the urban county in each analysis, while the set of suburban counties used to construct each urban-suburban dyad vary with the outer radius. Top row (left to right): 40 and 60 kilometer outer radius. Bottom row (left to right): 80 and 100 kilometer outer radius.