Chapter 4. How Interstate Highways Polarized Metropolitan Areas

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Abstract

Highways have changed the geography of metropolitan areas not only by creating more Republican suburbs, but by increasing the divide between suburbs and cities. Chapter 3 established that highways were responsible for the creation of new Republican suburbs, but did not address the Interstate Highway System's larger role in the widely documented trend of cities becoming more Democratic relative to their suburbs. This chapter estimates highways' effect on urban-suburban political polarization, the gap in the two-party vote between central and outlying counties in a metropolitan region. Adding a new measure of highways' spatial influence based on highways' connectivity to local street networks, the chapter uses a variety of robust methods to estimate causal effects on polarization in the 100 largest US cities. A range of model results uniformly generate positive point estimates, and demonstrate that a modest increase in urban highway density generates up to a 4 point increase in urban-suburban polarization, compared to the 10.5 point average increase in urban-suburban polarization between 1952 and 2008. These results establish that the present-day alignment of partisanship and residential location on an urban-to-rural continuum is partially a consequence of the federal highway policies. A public policy with the potential to bring Americans closer together instead allowed them to live among individuals with similar political preferences, worsening the political disconnect between major cities and their hinterlands.

One of the striking aspects of the red-blue map of presidential election results is the substantial partisan divide between major cities and their outlying areas. Once standard presidential election maps are adjusted to account for population, it becomes clear that cities are the base of the Democratic Party and outlying areas are the base of Republican politics, a pattern that largely holds true regardless of region (Gastner and Newman, 2004). Even in Republican states like Texas, Democrats have an edge in urban politics. In Utah, where only 34.2% of voters cast ballots for Barack Obama in the 2008 presidential election, residents of the city of Salt Lake County gave 50.1% of their votes to Obama. In Texas, a state that has not cast a plurality of its votes for a Democratic presidential candidate since 1976, voters in Dallas, Houston, San Antonio, and Austin routinely cast a majority of their votes for the Democratic presidential candidate. But these cities still exist in a sea of counties dominated by the Republican vote, starting with the suburban counties that surround them. Even in the deeply Democratic "blue states," a large gap exists between the urban and suburban vote. The boroughs of New York City, for example, cast 74 percent of their presidential votes in 2008 for Barack Obama, while other counties within 80 kilometers of Manhattan cast only 61 percent of their votes for the Democrat.

[1]This chapter argues that the construction of Interstate highways from city centers to outlying areas, and between outlying areas, has deepened this urban-suburban divide in American politics. While Chapter 5 demonstrates that the effects of highway construction can be highly localized within municipalities and counties, this chapter demonstrates that the localized effects translate into metro-level effects. Highways distributed more population into suburban areas, helping to produce new "edge cities" in suburban counties (Garreau, 1991) and opening up wide expanses of land outside cities to so-called "greenfield" development on undeveloped land, attracting the type of individuals willing to accept the difficulty of a long freeway commute in exchange for larger homes and lots (Stutzer and Frey, 2008; Meyer, Kain and Wohl, 1971).

[2]Moreover, even as the freeway system made suburban residence more attractive to some citizens, it reduced both neighborhood attractiveness and quality of life in urban areas, destroying some urban neighborhoods, exacerbating disorder in others, and otherwise undermining the aesthetic appeal of urban life.

Shifting the focus from the local level to the metropolitan level, this chapter considers the implications of

[1]For a glossary on the jargon of suburban development, see Hayden and Wark (2004).

[2]For the best histories on the urban impacts of freeway construction, see Mohl (1993) and Mohl (2004). In Chapter 5, I discuss freeways' impact on central cities and the controversies that emerged in the wake of freeway construction.

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highway construction for the partisan gap between cities and their environs, as measured by urban-suburban difference in the Democratic vote. Adopting a monocentric model of metropolitan political development, I examine how highways have contributed to the growing gap between urban cores and outlying areas. Applying different metrics of highway construction based on radial highways (or "rays") (Baum-Snow, 2007) and the density of Interstate Highway System exits, I show that a modest increase in the density of highways' connectivity in a metropolitan area (from the 25th to the 75th percentile) increases the urbansuburban gap in the Democratic vote by almost four points. Matching-based estimators yield estimates of an increase in the urban-suburban vote gap about three points across the interquartile range, with varying degrees of precision.

1 The Enduring Utility of the Monocentric Urban Model

1.1 The Value of the Monocentric Model in Urban Social Science Research

In analyzing the urban-suburban vote gap using county-level voting data, I adopt a monocentric representation of urban political geography. This model borrows monocentric models adopted in economics (Alonso, 1964; Muth, 1969; Mills, 1967) and urban sociology (Burgess, 1925). In its basic form, this model proposes that all jobs are located in a single central business district (CBD), and commuting costs increase with increasing distance from the CBD. In the simplest form of the monocentric model, if residents equally substitute the value of their time and the value of housing-associated benefits, this should lead to greater density and higher rents near the city center. As urban areas have become more multipolar, with multiple commercial and industrial employment centers and decentralization of industries (Jackson, 1985), this monocentric model appears to have lost its value in the study of urban transportation and land use, and substantial urban research in the last two decades has attempted to develop alternatives, though with limited success (Richardson, 1988). Most twentieth-century urban geography utilized some version of the monocentric model, led by members of the Chicago School (e.g., Burgess 1925). More recent scholarship in the Los Angeles School (e.g., Dear (2000)) develops a multicentric model of urban development to better explain the growth of more sprawling cities typically found in the American West and in other regions that expanded during the automobile era, with Los Angeles serving as the archetype of the multi-centered city. However, attesting to the value of the monocentric approach, multicentric models are often just an attempt
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to generalize findings from the monocentric case. For different reasons, a monocentric model is also applicable to the study of the political metropolis,

even if analyses centered on the city are no longer applicable in the study of residential choice and urban development. In studying political geography, we are not as dependent on the assumptions that underpin economic models of urban development. From the mid twentieth century to the present, a monocentric model has captured the centering of Democratic votes in cities, first organized by urban political machines and, gradually over time, increasingly as a consequence of residential sorting. In the 1950s, the polycentric metropolises of the last four decades, ranging from Phoenix to Los Angeles, had yet to expand into large metropolises with multiple centers. For example, among the cities of Phoenix, Mesa, Glendale, Scottsdale, and Chandler, all of which currently rank among the 100 largest U.S. cities but constitute a single metropolitan area, only one, Phoenix, had made the list in 1950 (at 99th place). The growth of new suburban commercial and industrial hubs is an important outcome that occurred primarily after the construction of major highways. Changes to other aspects of urban geography that either accompanied or contributed to changes in the political geography do not impede these efforts. (Indeed, to the extent that such changes precede political change, they simply represent a mediating variable between highway construction and political outcomes.) To the extent that suburban centers have supplanted urban central business districts in residential and commuting patterns, such non-political developments can be considered post-treatment to highway construction.

1.2 Empirical Support for a Monocentric Model of Metropolitics

While monocentric models of urban economics are dependent on strong theoretical assumptions, a monocentric model of politics can be justified on empirical grounds. Even though much of the metropolitan growth in the United States has occurred in large suburban edge cities and multicentric Sun Belt metropolises, a monocentric political geography remains the rule rather than the exception in the United States. Over the past fifty years, suburban and rural counties have become more Republican relative to central city counties. With a few exceptions, the familiar red-blue electoral map consists of urban Democratic oases in a sea of Republican rural and suburban counties. Across much of the midsection of the country, especially, urban-suburban polarization has been especially strong, with voters in the central counties of metropolitan areas casting their 2008 presidential votes for Obama by about a two-to-one margin, while

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outlying areas cast their votes for McCain by almost as large a margin. Even in uniformly Democratic coastal regions, central cities are heavily Democratic while outlying areas are only slightly Democratic.

1.3 Defining Urban-Suburban Dyads

[3]To assess the growth in urban-suburban polarization over time, the unit of analysis is defined as the urbansuburban dyad, consisting of the central (i.e., urban) county in the metropolitan areas built around the Top 100 U.S. cities as of 1950, and suburban counties defined by a distance-based rule.[4]While a number of reasonable coding assumptions may be used to define "urban" and "suburban" counties for the purpose of constructing dyads, I adopt a distance-based metric of core and periphery for purposes of this chapter. Following the coding standard adopted in the previous section, "urban" counties are those nearest the central city, while "suburban" counties are those that are not classified as urban but lie fewer than 80 kilometers from the center. 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." Examples of the counties used to assemble each urban-suburban dyad appear in Table 1.3.

While various rules can be adopted when defining a sample of major metropolitan areas, a sample based on 1950s population data permits inferences to the population of metropolitan areas that existed before construction of the Interstate Highway System. Thus the population of interest consists of urban-suburban dyads built around the 100 largest cities in the United States in 1950. Declining industrial cities like New Bedford and Fall River, Massachusetts make the list, but more recent boomtowns like Colorado Springs,

[3]Presidential 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 errata in the ICPSR files, 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.
[4]The center is defined using the central point that appears in the ESRI StreetMaps USA 2008 "Major Cities" layer (ESRI, 2008a).
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Dyad	Urban Counties	Suburban Counties
Milwaukee	Milwaukee, WI	Kenosha, WI
		Ozaukee, WI
		Racine, WI
		Washington, WI
		Waukesha, WI
San Francisco/Oakland	Alameda, CA	Contra Costa, CA
	San Francisco, CA	Marin, CA
		San Mateo, CA
Indianapolis	Marion, IN	Boone, IN
		Hamilton, IN
		Hancock, IN
		Hendricks, IN
		Johnson, IN
		Madison, IN
		Morgan, IN
		Shelby, IN
		Tipton, IN

Table 1: Examples of urban-suburban dyads, and the urban and suburban counties aggregated to produce them.

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[5]San Jose, and Las Vegas do not. Small cities that fall within the catchment area of a larger metropolitan area are merged into the larger metropolitan area, along with their hinterlands. The list of 100 cities is reduced once cities that fall within the catchment area of another, larger city are merged into the metropolitan area, producing a de facto multicentric area. Following these coding decisions, the number of sample dyads falls to n= 73.

1.4 The Secular Increase in Urban-Suburban Polarization

The outcome of interest, urban-suburban political polarization, is defined throughout analyses as the difference between 1952 and election year t in the difference between urban and suburban counties in each metropolitan area. An increase in this quantity in response to additional highway construction implies that highways have increased urban-suburban polarization. By making metropolitan regions the unit of analysis, rather than the sample of all voters living in urban or suburban areas (as one would commonly do with individual-level survey data on place of residence), it is apparent that the growth in urban-suburban polarization is a widespread phenomenon across multiple metropolitan areas.

Let D_{ist} represent the Democratic vote share in suburban counties in metro area i in year t, and D_{iut} represent the Democratic vote share in the urban counties in metropolitan area i in year t. The outcome of interest used throughout the paper is the urban-suburban difference in the urban-suburban gap in the Democratic proportion of the vote between 1952, the final election year before initial construction of the Interstate Highway System, and year t, in each metropolitan area:

$$\Delta_{i;t} = (D_{iut} - D_{iu;\,1952}) - (D_{ist} - D_{is;\,1952}) \quad (1)$$

A plot of $\Delta_{i;2008}$ [5], the change in the urban-suburban difference in the Democratic vote between 1952 and year t, appears in Figure 1. Taking the unweighted average of all metro areas in the sample, this shift was about 10.5 percentage points, though, like the results from the suburban county-level analysis in Chapter 5, the increase in polarization varies by region. While metro areas across the country have become increasingly

I explored the use of municipal-level election returns, which would have provided finer spatial resolution. 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. With these limitations in mind, this analysis is limited to county-level election returns.

[6]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.

2 Estimating Highways' Contribution to Urban-Suburban Polarization

[7]Interstate highways can be expected to yield both direct and indirect effects on the urban-suburban gap. Scholarship on suburban politics confirms that "ideological identification tracks the built environment" (Williamson, 2008), as political conservatism coincides with new housing stock, sprawl, and other indicators of suburbanization, while areas with fewer of these indicators of suburban growth are more likely to be politically liberal.Self-reported ideology aside, partisanship is also correlated with residential preference. Other recent research has shown that highways may be responsible for creation of suburbia, with population declining in central areas and growing in outlying areas as a consequence of highway construction. It follows that a public policy that produces new suburbs has the potential to polarize politics in a metropolitan area.

[6]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.
[7]To an extent, arguments suggesting that suburbia is politically diverse adopt a fairly limited definition of suburban, commonly excluding rural areas that have acquired a more suburban (or exurban) character.
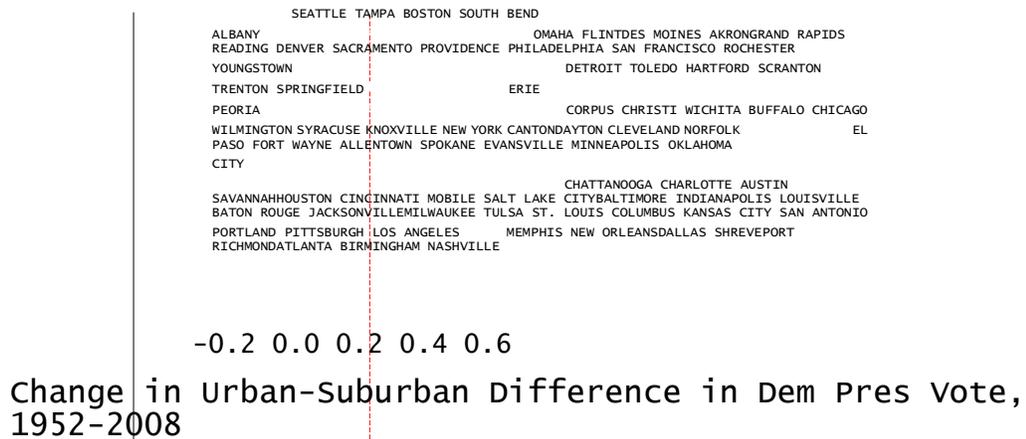
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                       SEATTLE TAMPA BOSTON SOUTH BEND
         ALBANY                            OMAHA FLINTDES MOINES AKRONGRAND RAPIDS
         READING DENVER SACRAMENTO PROVIDENCE PHILADELPHIA SAN FRANCISCO ROCHESTER
         YOUNGSTOWN                            DETROIT TOLEDO HARTFORD SCRANTON
         TRENTON SPRINGFIELD                ERIE
         PEORIA                              CORPUS CHRISTI WICHITA BUFFALO CHICAGO
         WILMINGTON SYRACUSE KNOXVILLE NEW YORK CANTONDAYTON CLEVELAND NORFOLK          EL
         PASO FORT WAYNE ALLENTOWN SPOKANE EVANSVILLE MINNEAPOLIS OKLAHOMA
         CITY
                                       CHATTANOOGA CHARLOTTE AUSTIN
         SAVANNAHHOUSTON CINCINNATI MOBILE SALT LAKE CITYBALTIMORE INDIANAPOLIS LOUISVILLE
         BATON ROUGE JACKSONVILLEMILWAUKEE TULSA ST. LOUIS COLUMBUS KANSAS CITY SAN ANTONIO
         PORTLAND PITTSBURGH LOS ANGELES     MEMPHIS NEW ORLEANSDALLAS SHREVEPORT
         RICHMONDATLANTA BIRMINGHAM NASHVILLE


           -0.2 0.0 0.2 0.4 0.6
      Change in Urban-Suburban Difference in Dem Pres Vote,
      1952-2008
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Figure 1: Shift in the urban-suburban gap in the Democratic presidential vote in leading metropolitan areas, 1952 to 2008.

Adopting the same units of analysis and outcomes of interest as in Section 1.2, I incorporate information on highway construction and covariates believed to predict both highway construction and electoral results. The main analyses in this chapter estimate the extent to which the relative density of highways in each metropolitan area contributes to the growth in urban-suburban polarization, using two metrics: the number of Interstate highway exits per square mile and the number of radial highways, or "rays," emanating from each city center (Baum-Snow, 2007). Each measure provides a different gauge of highways' ability to provide overall mobility, potentially facilitating the partisan split between the core and periphery.

2.1 Highway Exits as Local Connections

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,

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[8]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 capillaries of local street networks. Data on these exit locations are drawn from the 2008 StreetMapUSA exits layer (ESRI, 2008b). To develop a panel data measure of exit construction, I merged the exits data 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, geocoded in one-mile segments.[9]To establish the opening date for each exit, I linked these geocoded points 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. The count of exits is then divided by the total land area in the metro-area dyad. The resulting variable captures Interstate highways' overall presence in each metro area each year between 1956 and 1996, taking into account the physical geography of the area.[10]The effect of the exits variable is estimated under several functional form assumptions, using both linear and log-transformed versions of the treatment variable.

2.2 Radial Highways as Conduits

The second variable used for these purposes 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), shows that additional

[8]Baum-Snow (2007) assigned geographic locations to the nearest mile, interpolating between the start and end points of each freeway project segment. As 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, but in rural areas typically run from one end of a county to another. These maps were stored in a Federal Highway Administration mainframe. Though the original data have been lost or misplaced by the FHWA, other researchers, including Baum-Snow (2007), have retained copies of the data from earlier research projects.
[9]Based on a reading of archival records on highway construction in state and federal archives, exit construction occurred concurrently with initial highway construction.
[10]I consider presidential election results through 2008. Because the PR-511 data terminate in 1996, by which point construction on the Interstate Highway System was substantially complete, information on highway exits is updated only through that year.

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[11]highways should 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 singlefamily 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.[12]Beyond simple economic motivations related to housing stock, such highways also subsidize residents preferring suburbs for their schools, low crime levels, 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.

An illustration of the construction of a single dyad and associated treatment variables appears in a map of the Atlanta metro area in Figure 2. As one of the most freeway-dominated and automobile-dependent cities in the United States, arising in part from its role as the major transportation hub for the Southeast, Atlanta is a very highway-dependent metropolitan area. A majority of Georgia commuters spent more than 20 minutes commuting to work in 2000. On average, Atlanta metropolitan area residents spent 31 minutes commuting per day, more than 134 hours in the course of a 260-day work year. Just under 70% of those

[11]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). This suggests that with increasing income, people are more willing to trade away their time for more land and space. On balance, highways may subsidize this form of luxury consumption.

[12]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.

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workers drove to work alone (Transportation Research Board, 2006, 86,108). On the map, an 80-kilometer buffer centered on the city of Atlanta delimits the scope of the metropolitan area. Counties other than Fulton County whose centroids fall inside the buffer are merged to construct the suburban sample. Data used to construct each treatment variable appear on the map. The map enumerates each of the six highway rays extending from the city center. Interstate highway exits appear as blue-green points along each Interstate highway.
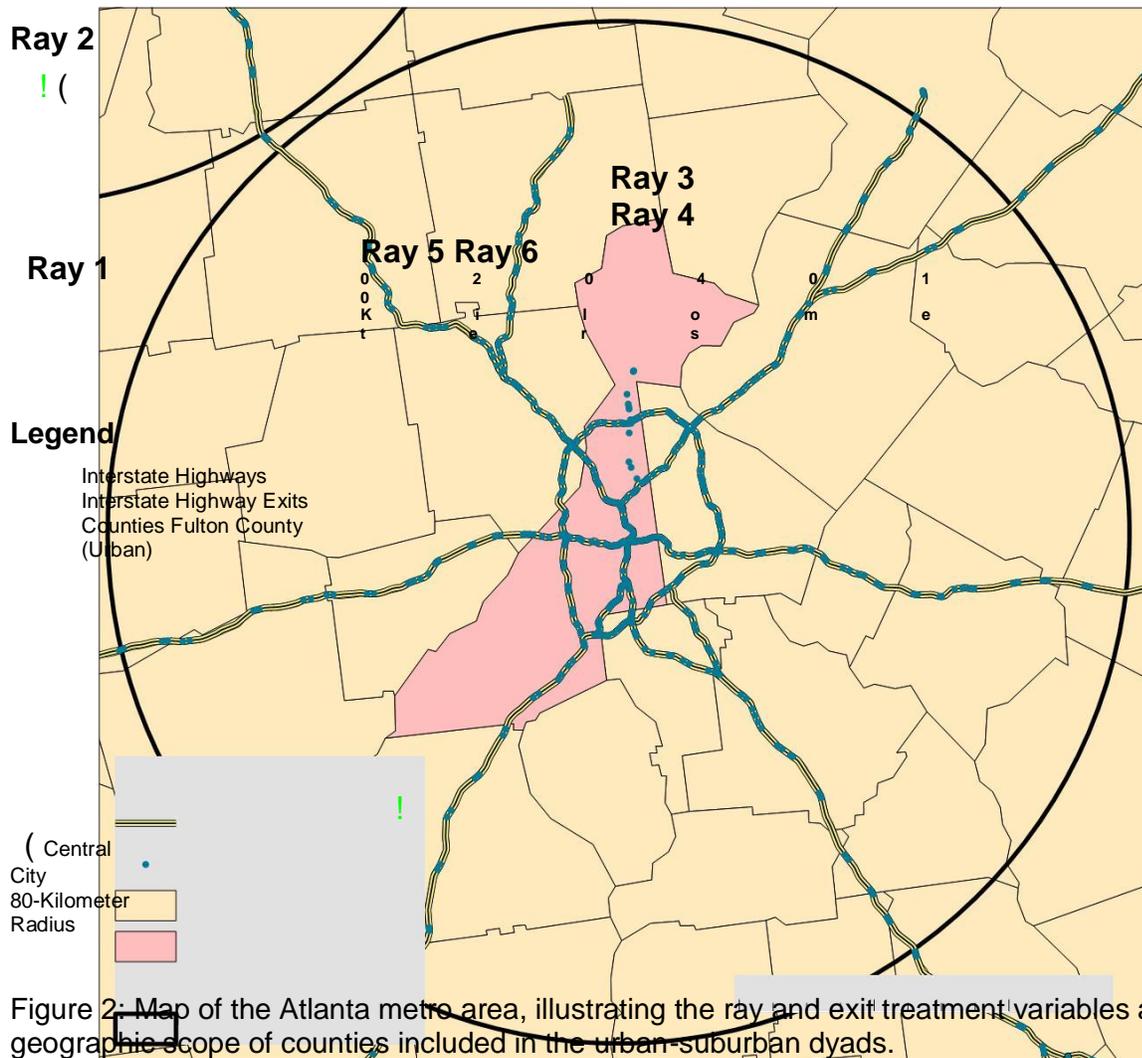
Figure 2: Map of the Atlanta metro area, illustrating the ray and exit treatment variables and the geographic scope of counties included in the urban-suburban dyads.

Covariates: A common set of covariates obtained from Census and electoral data are used in models for both the exit-based and ray-based analyses. Electoral variables include the lagged outcome of interest–the

[13]urban Democratic vote minus the suburban Democratic vote–for the years 1948 and 1952. These variables predict much of the subsequent realignment in county voting patterns. Census variables include both the within-dyad difference and unweighted mean of the non-white fraction of the population. These capture, to the extent possible using Census data, the potential role of racial heterogeneity as a contributor to white flight and residential sorting. An indicator for states 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 party preference in most of the Solid South varied from the rest of the country quite strongly across the first few decades of the 1952-2008 study period.[14]Finally, log population density is a predictor of two important variables: the density of freeways under the rays measure and the metropolitan Democratic vote.

Estimation: To establish the robustness of the findings, multiple estimation methods are used. The core analysis uses ordinary least squares regression, tracking the growth in polarization after 1952 as a function of the highway treatment. Setting $_t$ as the vector of $_{i,t}$ values (the difference in the urban-suburban gap in the Democratic vote in dyad i between year t and 1952), the causal effect of the treatment variable z_t (exits, log exits, or rays at election year t), $_{z_t}$, is estimated along with other parameters by OLS regression assuming the following linear model:

$$_t = _0 + _{z_t}Z_t + _2X_1 + \cdots + _kX_k + \quad (2)$$

where $_{z_t}$ represents the causal effect of a one-unit change in the relevant treatment variable, is the difference in between 1952 and year t in the urban-suburban difference in the Democratic proportion of the presidential vote, and $x_1, \ldots, x_{kt}$ represent included covariates. A secondary estimation approach applies instrumental variables methods, using two-stage least squares

to estimate the effect of the rays variable, using highways that appear on a 1947 highway planning map as an

[13]This "Southern exceptionalism" appears to have held until recent years, with Southern voting behavior increasingly in line with the rest of the country (Shafer and Johnston, 2006).

[14]At least since Epstein (1950), political scientists have observed that the Democratic two-party vote has been proportional to the "size of place." Though Epstein observed this relationship in Wisconsin, other scholars were able to replicate the findings with varied success. However, one consequence of the secular increase in urban-suburban polarization is that the "size of place" relationship has become stronger.

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Variable	Mean	SD	Min.	Max.
Treatment Variables				
Highway Rays Planned	3.11	1.39	0	0.214
Highway Rays Built, 1960	1.87	1.52	0	6
Highway Rays Built, 1970	3.39	1.40	0	7
Highway Rays Built, 1980	3.51	1.38	0	7
Highway Rays Built, 1990	4.04	1.44	0	7
Exits Open Per Square Mile, 1956	0.005	0.009	0	0.056
Exits Open Per Square Mile, 1964	0.023	0.033	0.007	0.214
Exits Open Per Square Mile, 1972	0.038	0.042	0.016	0.222
Exits Open Per Square Mile, 1980	0.046	0.053	0.018	0.266
Exits Open Per Square Mile, 1988	0.048	0.053	0.020	0.266
Exits Open Per Square Mile, 1996	0.049	0.054	0.006	0.266
Covariates				
Urban-Suburban Diff. in Dem. Pres. Vote, 1948	0.034	0.091	-0.201	0.262
Urban-Suburban Diff. in Dem. Pres. Vote, 1952	0.033	0.098	-0.169	0.250
Urban-Suburban Diff. in Dem. Pres. Vote, 1956	0.022	0.095	-0.202	0.281
Urban-Suburban Difference, Proportion Nonwhite, 1950	0.030	0.608	-0.132	0.185
Urban-Suburban Mean, Proportion Nonwhite, 1950	0.103	0.114	0.003	0.440
Log Persons/Sq. Mi., 1950	5.10	1.066	3.74	9.57
South	0.293	0.455	0	1

Table 2: Summary statistics, covariates used to construct suburban dyads.

[15]instrument for subsequent highway construction (Baum-Snow, 2007).[16]Urban economists adopt variations of this instrument to address their primary 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 maps of 1898 railway routes, arguing that railway maps guided the selection of feasible inter-city highway routes and rights of way (Duranton and Turner, 2008).

[17]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 rather than reducing it, and with no way of assessing the potential direction of the bias.In brief, instrumental variables regression is suitable as another estimation method, but is

[15]The highway map used by Baum-Snow is an updated version of a plan that appeared in the 1944 "Interregional Highways" report that established the contours of the Interstate Highway System.
[16]One reason for this choice of instrument is physical determinism. While the Interstate Highway System developed new rights of way through difficult terrain, physical geography has been an important obstacle to American economic expansion and infrastructure improvements. For example, the long absence of suitable roads from the East Coast to the American West was not only a consequence of federal inability to coordinate development of major public works projects (Weingast and Wallis, 2005). The largely impassible Appalachian mountain range was also responsible. Furstenberg (2008), for example, notes that the most important transportation project of the early nineteenth century, the Erie Canal, was located in the sole gap along the Appalachian range that permitted a canal between the East Coast and the Northwest. With the advent of the steam shovel, dynamite, and other construction technology, many physical obstacles diminished in importance.
    [17]Following other instrumental variables analyses, Baum-Snow (2007) repeats the widely held belief that the Interstate Highway

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not inherently less biased than combinations of matching, difference-in-difference, and linear-model-based estimation.

[18]Finally, I dichotomize the treatment variables and generate 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.[19]Using genetic matching (Diamond and Sekhon, 2005), I create a matched sample of treated and similar untreated units. This method generally yields better improvements in balance in small samples than other matching methods, with the cost of introducing additional imbalance on some variables.The genetic matching algorithm employs the same set of covariates that appear in the linear regression models, and those models are 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.

For each set of estimates, I estimate z_t and other parameters independently for all presidential years between 1960 and 2008, then smooth nonparametrically across the estimates of z_t[20]using locally weighted (lowess) regression (Cleveland and Devlin, 1988). Confidence intervals are assembled by bootstrapping point estimates, then smoothing across each bootstrap estimate to generate the simulated confidence envelopes by selecting the appropriate quantiles from a set of 1000 lowess-smoothed bootstrapped estimates. Smoothing permits incorporation of information from nearby point estimates to construct more accurate confidence intervals. Without this smoothing, confidence intervals would be too conservative.

System was designed with military prerogatives in mind, a belief that greatly 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.

[18]Dichotomizing the treatment incorporates an assumption that the "dose" of the treatment of interest is identical for units above the median and for units below the median.

[19]This is a general problem facing all matching methods that assume that data are ellipsoidally symmetric, i.e., that assume that the data are multivariate t - or normal-distributed (Rubin, 1976). When sufficient observations are available, exact matching or coarsened exact matching are preferable, as they either bound or eliminate this additional imbalance (Iacus, King and Porro, 2009).

[20]For the non-matched samples, each observation is given equal weight in the bootstrap sampling. For analyses based on the matched samples, observations are resampled with a probability proportional to the weights generated during matching with replacement. This permits inference to the population represented by treated units.

15

3 Results

I sequentially present results under the two approaches to measuring highways as metro-level treatments. I begin with the more favored of the two measures, the density of exits in each metropolitan urban-suburban dyad. I then present results of the analysis based on highway rays, the preferred measure in the urban economics literature.

3.1 Results Based on Exit Density as a Treatment

The first set of results consists of effects of the number of exits per square mile in each metropolitan area, under two functional form assumptions: a linearity assumption and a logarithmic transformation of the explanatory variable. The substantive implication of the log transformation is that increasing highway connectivity produces diminishing marginal strength of treatment: as the number of highways increases, the strength, or dose of the treatment increases less quickly. Highways' effect on urban-suburban polarization is robust under both model scenarios.

[21]A model using the log-transformed version of the exits per square mile variable also yields 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 urbansuburban gap in the Democratic 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 3).[22]The null of no effect can be rejected at standard levels through the 2008 election.

Matching "treated" observations (those with a highway exit density greater than the sample median) to "untreated" observations (those with a highway exit density below the sample median) greatly reduces imbalance. For almost all covariates in most years, matching reduced the imbalance to below 0.5 standard deviations of each variable in the pre-matched treatment group. Applying a linear model to the matched sample using a matched sample based on dichotomized exit density yields somewhat smaller estimates of

[21]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.

[22]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, a period approximately comparable to the period during which localized effects were robustly observed in suburban counties (Ch. 3).

16

**Effect of Log
Highway Exit
Density on
Polarization
Difference Across
IQR of Exits/Sq.
Mi. Variable**

1988

1992

1996

2000
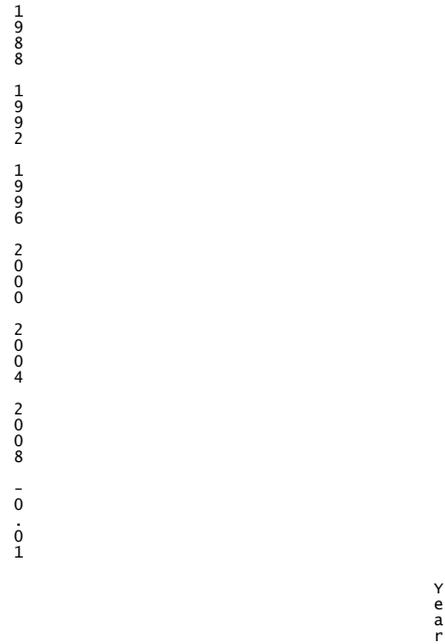
2004

2008

-0.01

Y
e
a
r
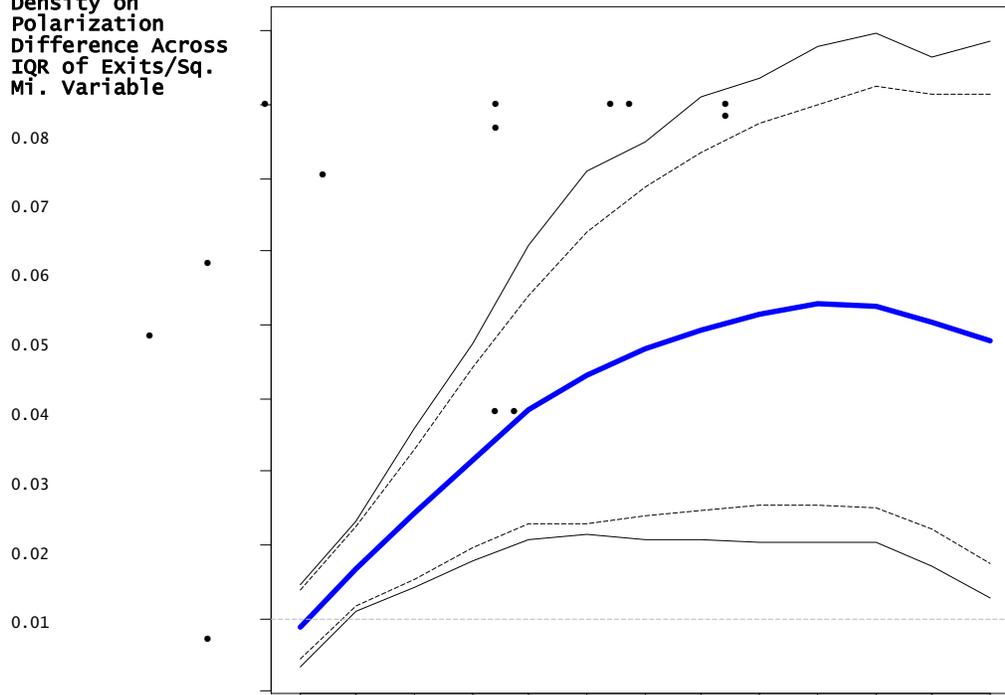
Figure 3: Causal effect of highways on urban-suburban polarization in the Democratic presidential vote, 1960 to 2008. Treatment variable is measured using the log of the number of exits per square mile in the metropolitan area. Bootstrapped 95% (solid line) and 80% (dashed line) confidence envelopes are generated from the lowess-smoothed curves to incorporate information from proximate observations. Unsmoothed bootstrapped estimates appear as points.

the treatment effect

than were obtained using the continuous version of the treated variable. A direct comparison between these results is not possible, both because of the transformation of the treatment variable and because inferences are made to a different sample. However, even with changes in the sample and modeling assumptions, increasing the number of highway exits from below the median to above the median, holding all else constant, increases the urban-suburban presidential vote gap by approximately two percentage points.

3.2Results Based on Rays as Treatments

Similarly large estimates are obtained for the rays variable, 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

17
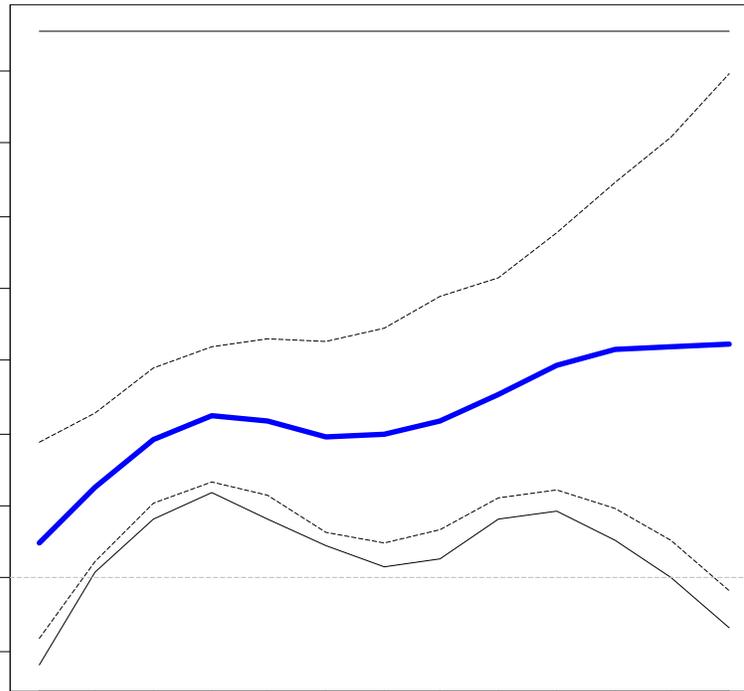
**OLS Estimates of Average Treatment Effect on
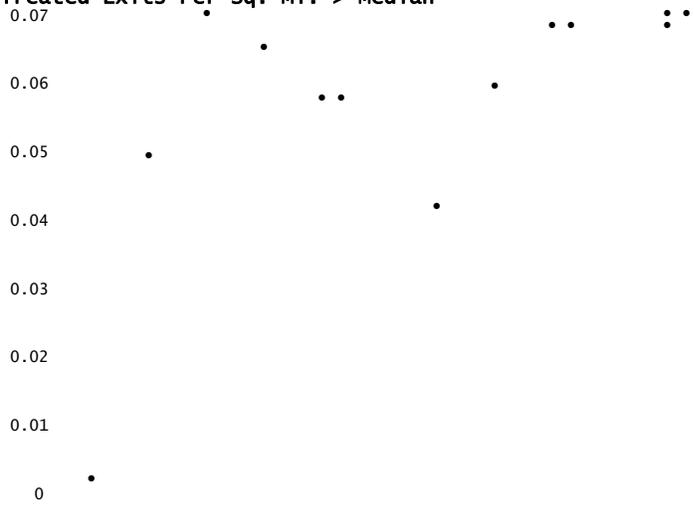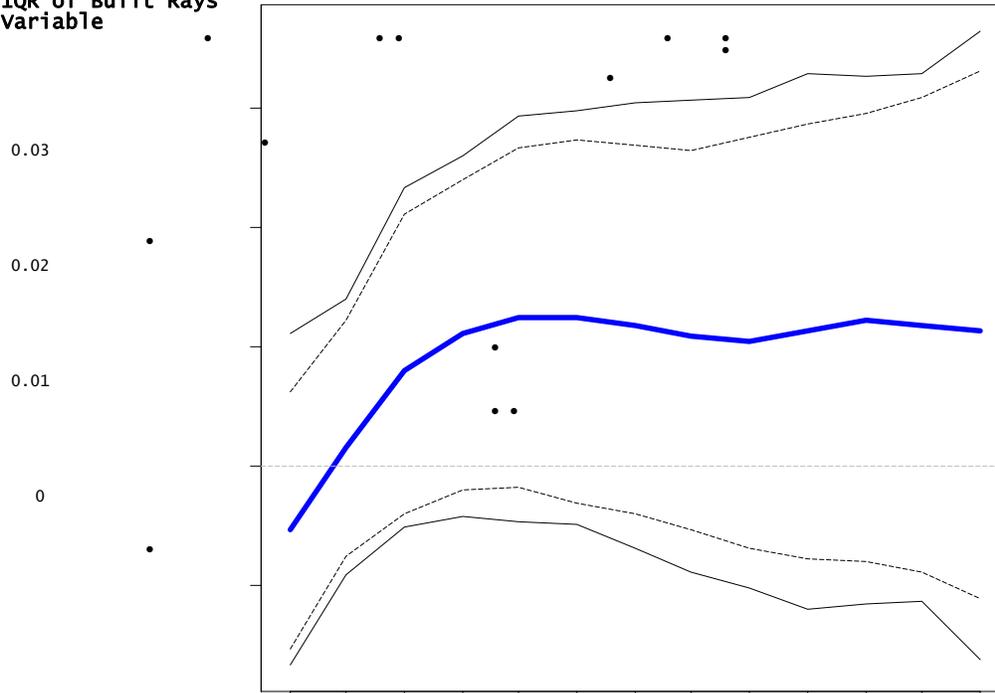Treated Exits Per Sq. Mi. > Median**

Figure 4: Effect of highways on the urban-suburban Democratic vote gap, estimated by least squares regression on the matched sample. The estimate captures the difference in the urban-suburban Democratic vote difference, shifting the number of built rays from below the median in year tto above the median. Bootstrapped 95% (solid line) and 80% (dashed line) confidence envelopes are generated from the lowesssmoothed curves to incorporate information from proximate observations. Unsmoothed bootstrapped estimates appear as points.

Highway Act. The causal effect of moving across the interquartile range of the planned rays variable–from two to four rays–appears in Figure 5. 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 5). Point estimates are positive and are close to statistical significance at the 80% confidence level across most of the study period. Two-stage least squares estimation (Figure 6), which uses proposed rays as an instrument for subsequent highway construction, produces a larger and more precise estimate of about 3 percentage points when the number of rays increases from two to four, and the 95% confidence envelope barely covers the null value of zero effect.

As in the case of the exits variable, matching treated observations (metro areas with more highway rays

18

OLS Estimates First
Difference Across
IQR of Built Rays
Variable

0.03

0.02

0.01

0

-
0
.
0
1

1
9
6
0

1
9
6
4

1
9
6
8

1
9
7
2

1
9
7
6

1
9
8
0

1
9
8
4

1
9
8
8

1
9
9
2
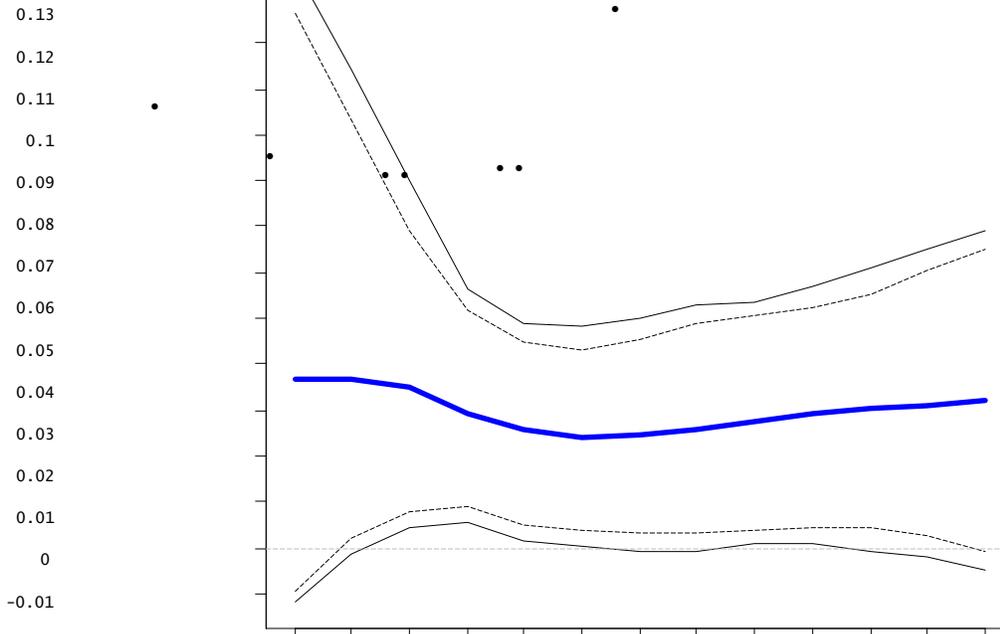
1
9
9
6

2
0
0
0

2
0
0
4

2
0
0
8

Y
e
a
r

Figure 5: 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.

than the median) and untreated observations (those with fewer rays than the median)

substantially reduces imbalance between the treated and untreated groups. Matching samples exposed to the rays "treatment" reduces standardized imbalance on included covariates below 0.5 standard deviations for all variables, and below 0.2 standard deviations for most variables in most years, a superior reduction in the previous matching analysis, though imbalance was lower before matching under the exits-based scenario. Under this matching design, a shift in the number of rays from below the sample median to above the sample median produces, by 2008, a 3-point increase in urban-suburban polarization.

19

Change in Urban-Suburban Dem. Vote Gap, 1952-(Year)

**Effect of Rays,
2SLS Estimates
First Difference
Across IQR of
Planned Rays**

0.13

0.12

0.11

0.1

0.09

0.08

0.07

0.06

0.05

0.04

0.03

0.02

0.01

0

-0.01

1960

1964

1968

1972

1976

1980

1
9
8
4

1
9
8
8

1
9
9
2

1
9
9
6

2
0
0
0

2
0
0
4

2
0
0
8

Y
e
a
r

Figure 6: 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). Planned highway rays on a 1947 highway map are the instrument, while constructed rays at the nearest Census year constitute the endogenous treatment. 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.

3.3 Alternative Specifications

The results also hold under a range data specifications, establishing that results are not sensitive to the definition of the suburban catchment area. Extending 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 outer radius from 80 kilometers to 60 kilometers yields estimates that remain statistically significant across most of the post-treatment

study period, while
reducing the outer
radius to 40
kilometers (24.8
miles) from the city
center reduces the
magnitude and
increases the
20

Change in Urban-Suburban Dem. Vote Gap, 1952-(Year)

1960 1964 1968 1972 1976 1980 1984 1988 1992 1996 2000 2004 2008
Year
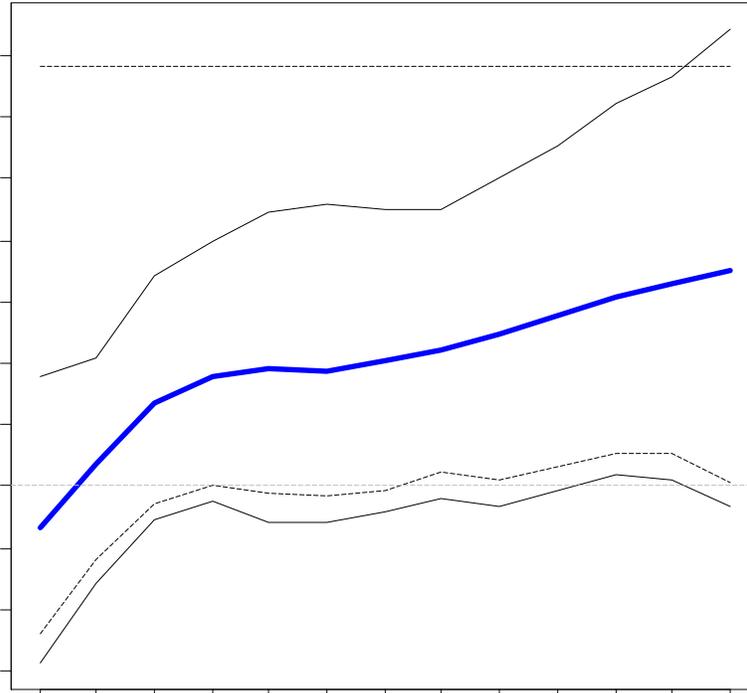
OLS Estimates of Average Treatment Effect on
Treated Rays > Median

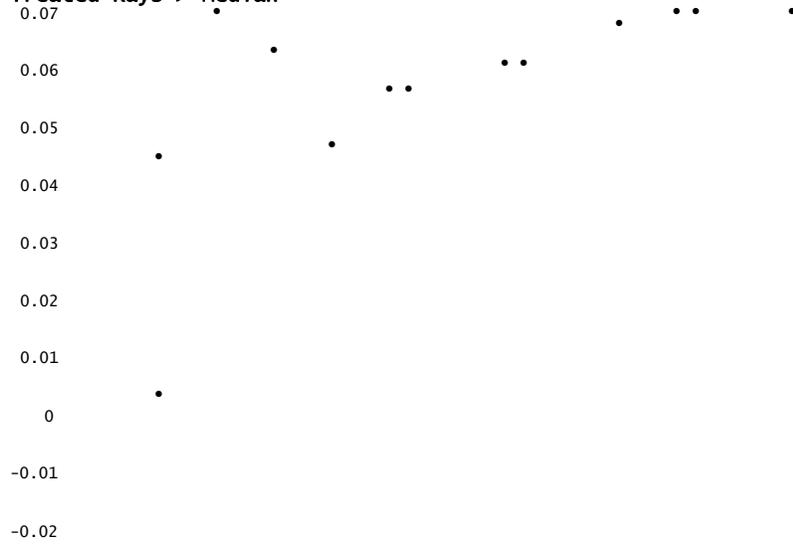0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02

-
0
.
0
3

Figure 7: 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.

[23]uncertainty of the estimates. This variation in the results suggests that a fraction of the observed result stems from political developments in the lower-density, more remote sections of cities' hinterlands (McKee, 2008). To the extent that highways have had an effect on polarization, then, they appear to have done so largely by driving creation of "exurbs" that become centers of Republican support.

Difference in Partisan Polarization, 1951–2004

[23]Additional analyses appear in the replication archive.

21

4 Discussion

The findings in this chapter have shown that highways contributed meaningfully to the growing partisan gap between the heavily urbanized and suburban areas of American metropolitan areas. Under certain specifications of the highway "treatment," metropolitan areas with more highways than average (at the 75th percentile of highway density) endured an urban-suburban Democratic vote gap 3 to 4 points larger than that endured by metropolitan areas with fewer highways than average (at the 25th percentile of highway density). Considering the average 10.5 percent shift between 1952 and 2008, much of which occurred late in the study period, the magnitude of this causal effect is almost a third as large as average growth in polarization. Even under data specifications that are less favorable to the highway-polarization hypothesis, analyses yield point estimates that are uniformly positive, with 80% and 95% confidence intervals that permit rejection of all but the most trivial negative effects.

A likely criticism of these results is that many other causes may have been responsible for urbansuburban polarization. However, this chapter has not attempted to identify the "causes of effects" (Holland, 1986), and has not even suggested that highways were the only cause of polarization. It has attempted to show that a public policy that changes space has not been neutral with respect to political outcomes. The construction of the Interstate Highway System–up to that point the largest public works project of the twentieth century–is one example of a government policy that could be expected to contribute to urbansuburban political polarization. Though nearly all observational research is subject to omitted variable bias, the adoption of regression, matching, and difference-in-difference estimation using covariates, account for many alternative causes, including racial threat, income, and regional realignments.

The fact that the Interstate Highway System's effect on metropolitan political geography may have occurred through non-political mediating variables does not undermine the importance of this result for American politics. Much of the theory behind the "feedback effects" of public policies on political behavior relies on mediating variables such as education (Mettler, 2002) and income (Campbell, 2003) as components of their explanation of public policies' effects on political participation rates. In the same spirit, highways may have accelerated polarization by influencing the other social and economic factors related to residential preference.

22

Given the long-running attention given to white flight since the 1970s, is it possible that the multiple models presented in this paper simply fail to account for the heterogeneity of "white flight" in different urban areas? Though this, like other forms of omitted variable bias, remains a possibility, the models used available data to account for this possibility, including adopting measures of the urban-suburban difference in the non-white percentage of the population to capture the gradient in racial heterogeneity between urban centers and outlying suburban areas. One aspect of racially motivated migration not easily accounted for in the models that I present is the role of interurban migration in the growth of the metropolitan areas in the sample. However, white flight was largely a response to ongoing internal conditions in each metropolitan area.

The urban-suburban partisan gap has grown not only because of individual sorting decisions, but because of the intervention of federal transportation 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 policies yielded concurrent political effects, highways enabled a subset of residents to respond to these ongoing urban changes by selecting from a range of residential options. Policies primarily intended to improve the operation of internal trade and intercity transportation with the goal of bringing Americans together had the unintended effect of allowing them to live apart. One unintended consequence for the American politics was a stronger political partition between declining urban areas and their hinterlands.
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