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NATIONAL POLICY FOR REGIONAL DEVELOPMENT: HISTORICAL EVIDENCE FROM APPALACHIAN HIGHWAYS

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ABSTRACT

How effective are policies aimed at integrating isolated regions? We answer this question in the context of a highway system in one of the poorest regions in the United States. With construction starting in 1965, the Appalachian Development Highway System ultimately consisted of over 2,500 high-grade road miles. We use a simple model of interregional trade to motivate our empirical analysis, which quantifies the relationship between market access and income. We then calibrate the model to evaluate the aggregate impact of the ADHS and compare this with alternative counterfactual proposals. We find that removing the ADHS would have reduced total income by $53.7 billion in the United States with $22 billion of the losses in Appalachian counties. Our findings highlight the potential aggregate benefits of transportation infrastructure policies, but also suggest that leakage outside of the targeted area may be substantial.

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1 Introduction

There are large differences in economic performance and individual outcomes across space within the United States and elsewhere. Policies that aim to integrate the national economy may facilitate growth through increased trading opportunities or increased productivity due to competition and the transfer of frontier technology to underdeveloped regions. At the same time, policymakers must balance concerns at the national level with policies that disproportionately benefit (or harm) particular regions. In the context of the United States, the counties in and around the Appalachian Mountains are among the poorest in the country with income per capita more than 20 percent below the national average.

In the early 1960s, the stark contrast between Appalachia and the rest of the country led the region's governors to lobby the federal government for relief. In 1965, President Johnson signed the Appalachian Regional Development Act, creating the Appalachian Regional Commission (ARC)–a federal-state partnership aimed at integrating the region–and fulfilling promises made by the Kennedy Administration. To date, over \$34 billion (in 2015 dollars) of federal expenditures have gone to the region, with the bulk of funding going to the construction of the nearly 2,500 miles of the Appalachian Development Highway System.[1] The construction of the Appalachian Development Highway System provides an opportunity

[1]The federal portion of expenditures under the Appalachian Regional Commission is similar in size to the Tennessee Valley Authority (TVA), a large-scale development project initiated as part of Franklin Roosevelt's New Deal. Total spending on the TVA was approximately approximately \$27.5 billion between 1930 and 2000. There was also a state and local matching component of the ARC that was up to an additional 30 percent of federal expenditures depending on the year over the program's history.

to study the long-run impact of a policy aimed at integrating isolated regions.

In this paper, we examine the impact of the Appalachian Development Highway System (ADHS) on regional development. Following Donaldson and Hornbeck (2016), we use a model of interregional trade with perfectly mobile labor together with newly digitized network data of the Appalachian, Interstate, US, and state highway systems in 1960, 1985, and 2010.[2] The model makes assumptions that are standard in the literatures on international trade and economic geography, and is useful for providing a tractable way to capture the direct and indirect effects of changes in trade costs. With this approach we are able to examine how changes at a particular point in the highway network influence any or all counties. This is important in our application, which examines regional transportation infrastructure in Appalachia, since the aggregate impact we calculate should reflect the role of trade costs in counties directly targeted by the infrastructure as well as counties that are indirectly affected.

We also use the model to motivative our empirical analysis and the interpretation of our main variable of interest, "market access," which measures each county's proximity to other counties based on the trade costs between county pairs using the highway network and market size. We start by computing the travel time between all county pairs in the contiguous United States: for 3,080 counties this gives over four million pairwise travel times. Following

[2]Some degree of labor mobility is appropriate for modeling the United States since the second half of the twentieth century. Importantly, this may lead to different implications for income or welfare following a change in trade costs than the case where labor is assumed to be immobile (Redding, 2016).

Combes and Lafourcade (2005), we convert travel time into trade costs using information on the cost of inputs for a typical freight shipment and construct "market access" as the proximity of a county to all other counties; specifically, market access for an origin county is the sum of the total income in each destination county weighted by trade costs. We then estimate the elasticity of total income with respect to market access. This elasticity together with counterfactual changes in the market access based on changes to the highway network allow us to quantify the aggregate impact of transportation infrastructure improvements.

Importantly, changes in the measure of market access used in the empirical analysis reflect changes in transportation costs due to improvements in the highway network as well as changes in a county's underlying productivity. In the empirical analysis we use county fixed effects to address concerns about highway placement with respect to time-invariant local productivity and state-year fixed effects to control for changes in state policy over time. In additional specifications we also control for local transportation infrastructure (i.e., highways, railroads, and proximity to ports), historical access to coal reserves and employment by sector, and a county's urban status. Finally, we use an instrumental variables strategy to isolate variation in changes in market access based on physical distance and the change in average speed between county pairs due to improvements throughout the transportation network.[3] This allows us to focus on changes in market access due to reduction in travel time over a fixed distance that are plausibly exogenous to the level or growth in local productivity

[3]Physical distance is the straight-line distance between county-centroid pairs and average speed is the the total travel time divided the distance travel along each route using the complete highway network.

that may have been targeted with highway improvements. Using the estimated elasticity, and holding the spatial distribution of population fixed, we estimate income losses from removing the ADHS between \$58 and \$88 billion using ordinary least squares and \$36 billion using instrumental variables.

As an alternative, we use our data to calibrate a simple structural model that allows for an endogenous reallocation of economic activity across space in response to counterfactual trade costs and find that removing the ADHS would have led to income losses of \$53.7 billion, which is equal to 0.4 percent of national income compared with 3.2 percent of gross national product due to the loss of agricultural land value from removing the US railroads in 1890 Donaldson and Hornbeck (2016) and 2.5 percent of real gross domestic product from removing India's Golden Quadrilateral Alder (2017). We also find roughly half of the benefits of the ADHS accrue to counties not included in the Appalachian Regional Commission, which suggests substantial leakage outside of the targeted area. Our findings suggest that the ADHS offset 11 percent of the decline in the national income share in Appalachia over the last five decades. To the put these results in context, we contrast the aggregate impact of removing the ADHS *and replacing it with alternative highways.* We consider an earlier proposal as part of the President's Appalachian Regional Commission, a proposal that focused on highway-building in the Lower Mississippi River Valley during the 2000s, and three extensions to the Interstate Highway System. In each case, we find that implementing any one of these proposals instead of the ADHS would have mitigated at most two-thirds of the loss from removing the ADHS.

Our paper contributes to a recent literature that combines trade theory and detailed measurement of trade costs to quantify the effect of transportation infrastructure (Donaldson, 2018; Donaldson and Hornbeck, 2016; Alder, 2017; Baum-Snow, Brandt, Henderson, Turner, and Zhang, 2017).[4] Our results also contribute to a large literature that applies reduced-form approaches to estimate the effect of highways in the United States (Baum-Snow, 2007; Chandra and Thompson, 2000; Duranton and Turner, 2012; Duranton, Morrow, and Turner, 2014; Isserman and Rephann, 1994; Michaels, 2008) and in developing countries (Banerjee, Duflo, and Qian, 2012; Faber, 2014; Ghani, Goswami, and Kerr, 2016; Jedwab, Kerby, and Moradi, 2016; Jedwab and Moradi, 2017; Jedwab and Storeygard, 2017; Storeygard, 2016). To this literature, we add estimates of the aggregate and regional implications of highway building in the United States in the second half of the twentieth century that take into account general equilibrium responses to changing trade costs.[5]

Finally, our results contribute to research focused on economic development in Appalachia and the effects of the Appalachian Regional Commission (Bradshaw, 1992; Black and Sanders, 2004, 2007; Haaga, 2004; Widener, 1990; Ziliak, 2012) as well as placed-based policies more generally (Glaeser and Gottlieb, 2008, 2009; Kline and Moretti, 2014). We focus exclusively on the impact of the new highway infrastructure due to the ARC, which requires special attention given the high share of appropriated funds going to the ADHS relative to other programs and the region's limited integration internally and with the rest of

[4]This is different from recent contributions by Allen and Arkolakis (2014, 2016) that use theory as well as information on trade flows and transport mode choice to construct endogenous trade costs for the more recent period in the United States. For the period we study going back to 1960, detailed trade flow and mode choice data does not exist.

[5]We also contribute newly digitized maps of the US highway network, which we use to measure county-to-county trade costs in 1960, 1985, and 2010.

the country. Importantly, the Appalachian Development Highway System still exists today and similar proposals elsewhere are under consideration.

The remainder of the paper is organized as follows. Section 2 gives an overview of the region's history and background for the creation of the Appalachian Regional Commission. Section 3 describes the highway network and county-level data used in the empirical analysis and quantitative exercises. Section 4 discusses a model of interregional trade that motivates our empirical specification. Section 5 presents the results from our empirical analysis, counterfactual exercises that remove Appalachian highways as well as alternative transportation interventions, and robustness. Section 6 concludes.

2 Historical Background

In *Night Comes to the Cumberlands*, Harry Caudill painted a grim picture of economic conditions in Eastern Kentucky and, more broadly, Appalachia circa 1960.[6] Caudill highlighted the poverty, isolation, exploitation, and destruction of natural resources as well as political backwardness within the region. In the early 1960s average household income in Appalachia was \$5,706 compared to \$7,349 nationwide. In addition, one-third of families in the region lived on less than \$3,000 per year compared to one-fifth in the rest of the country and unemployment in the region was pervasive (President's Appalachian Regional

[6] Caudill's *Night Comes to the Cumberlands* echoes the greater cultural attention paid to poverty represented, for example, by Michael Harrington's *The Other America*. Eller (1982) and Isenberg (2016) provide background on the economy and society of the Appalachian region from the colonial period through Reconstruction and the present. More recently, Vance (2016) provides an autobiographical account of Appalachian poverty since the 1980s.

Commission, 1964; Pollard, 2003). Over the next several decades differences with the rest of the country in terms of income, poverty, and unemployment narrowed. Despite these gains, policymakers and scholars remained concerned about the weakness of the labor market, deteriorating infrastructure, the slow rate of structural transformation, and lack of opportunity and mobility.

To combat poverty in the region, individual states initially used their own welfare systems to provide for displaced workers and promote growth. For example, Kentucky created the Agricultural and Industrial Development Board in 1946.[7] This and similar programs at the state level attempted to promote local development and provide subsidies to recruit industry from the North. In 1956, Kentucky created the Action Plan for Eastern Kentucky, which emphasized the need for a regional development authority to improve infrastructure, particularly through new highway construction (Eller, 2008, p. 47). In 1959, the same group established Program 60 to provide education, job training, health, and transportation investments, although the proposal failed to receive support from the state legislature.

In 1960, governors from several Appalachian states attended the Conference of Appalachian Governors, to develop strategies to lobby the federal government for assistance and cooperate in setting their own development goals. In the same year, then Senator John F. Kennedy visited West Virginia during a campaign stop and witnessed the poverty of the region first hand. This led to campaign promises to revitalize and invigorate Appalachia.

[7] This program was modeled after Mississippi's Balance Agriculture with Industry program established in 1936. Cobb (1982) provides an excellent overview of state-level policies for industrial recruitment starting during the Great Depression.

After his election, Kennedy promoted the passage of the Area Redevelopment Act in 1961, which promised relief funds for distressed regions. While the Conference of Appalachian Governors was eager to receive some funding, it became apparent these funds would not reach Appalachia due weak public finances at the state level and strict federal matching requirements. This was true even though 76 percent of Appalachian counties qualified as "distressed."

The Conference of Appalachian Governors continued to lobby President Kennedy and, following severe flooding in the region in 1963, the President's Appalachian Regional Commission (PARC) was created.[8] The commission was to provide recommendations to develop and integrate the region with the nation by January 1, 1964. The PARC report highlighted the lack of transportation infrastructure within the region as well as the absence of education and health services. Following Kennedy's assassination, Johnson promised to continue efforts begun under the previous administration. In the spring of 1964, the Appalachian Regional Development Act (ARDA) was proposed in Congress. At first the ARDA failed to receive sufficient support, however, the bill was resubmitted to Congress in 1965 following a few changes, the addition of Ohio and South Carolina as beneficiaries, and promises to Senator Robert F. Kennedy of New York to add 13 counties in New York at a later date. The modified ARDA was signed into law on March 9, 1965.[9]

The Act created the Appalachian Regional Commission (ARC) and initially designated

[8]The US Geological Survey estimated that the damages associated with the flood totaled $755 million in real 2015 dollars (USGS, 1968 p. B-56).

[9]In 1967, the ARC boundary expanded to include additional counties in Mississippi, New York, and others in states already in the program area.

counties in Alabama, Georgia, Kentucky, Maryland, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia to receive $1.1 billion in federal grants. Panel A of Figure A1 shows the program area of the ARC, including counties in Mississippi and New York that were added in 1967. The largest portion of funds, $840 million, was earmarked to create the Appalachian Development Highway System (ADHS) and the remainder was to be spent on education, health, and job training programs. The new highway system was intended to complement the expansion of the Interstate Highway System by providing connections to major population centers outside the region. Panel B of Figure A1 shows the aggregate federal ARC spending separately for highway and non-highway programs. By 2010, over $34 billion had been spent on ARC projects with $23 billion going to highways.

The initial PARC report highlighted the perceived importance of new transportation infrastructure: "Developmental activity in Appalachia cannot proceed until the regional isolation has been overcome. Its cities and towns, its areas of natural wealth and its areas of recreations and industrial potential must be penetrated by a transportation network which provides access to and from the rest of the Nation and within the region itself" (President's Appalachian Regional Commission, 1964, p. 32). In the initial authorization, over $489,000 per mile was authorized to transform steep, winding, narrow two-lane roads into highways with a straight alignment, low grade, additional lanes, and average travel speeds of 50 miles per hour or more. Many of the proposed segments were four lane roads that could handle vehicle speeds of up to 70 miles per hour (E.S. Preston & Associates, 1965).[10]

[10]Ultimately, improvements were substantial enough that three of the ADHS corridors

In the remainder of this paper, we use detailed data to document the growth of the US highway network and the specific contribution of the Appalachian Development Highway System to improved trading opportunities after 1965. We then quantify the impact of highway expansion on income and use these estimates to assess the aggregate impact of removing the ADHS. In addition, we ask how the impact of removing the ADHS was distributed across different US regions. In particular, we are interested in the extent to which gains were concentrated within the counties targeted by the Appalachian Regional Commission. This is important for understanding the specific impact of this policy as well as assessing the efficacy of using transportation infrastructure to facilitate regional development.

3 Data

The data for the empirical analysis are drawn from several sources. We use newly digitized maps of the highway network in 1960, 1985, and 2010 to compute the travel time between all county pairs in the contiguous United States in each year. In this section we discuss our representation of the highway network using geographic information system software and the details of calculating travel time. In the empirical analysis we combine the information on travel times with county-level data on income, population, and employment to examine the impact of the ADHS.

We use county-level data on total income, population, and employment in 1960, 1985, and 2010 from Haines (2010) and Bureau of Economic Analysis, U.S. Department of Commerce

were fully integrated as part of the Interstate Highway System: Corridor T in New York (I-86), Corridor E in Maryland and West Virginia (I-68), and Corridor X traversing Alabama and Mississippi (I-22).

(2015). We adjust county-level variables to reflect county boundaries in 2010 following the procedure in Hornbeck (2010) and merge independent cities in Virginia with the surrounding county to give a total of 3,080 observations in each year.

To calculate travel times we start by identifying each county as a point in space using the latitude and longitude of the county centroid. We then create a set of access roads that link the county centroids to neighboring counties with straight line connections. These two parts of the network are fixed in 1960, 1985, and 2010 and a constant speed of 10 miles per hour is assigned to all travel on access roads in each year.[11] Next, we overlay the highway network–including the Appalachian, interstate, national, and state highway systems–corresponding to 1960, 1985, or 2010.[12] The relative importance of each portion of the network for a given route will depend on the distance to be travelled and the assigned speed on each road type. In the online appendix, Figure A2 shows the extent of the highway system in 1960, 1985, and 2010. For each year, the panels of Figure A2 show the Interstate Highway System as thick black lines and the other portions of the highway network as thin gray lines.

To construct the network for 1960 shown in Panel A of Figure A2, we digitized state level maps from the 1959 Rand McNally Road Atlas. In particular, we digitize state highways, US Highways, and Interstate Highways. For both state and US Highways, we separately code three road surfaces; unimproved, improved, and paved. To obtain travel speeds, we refer to

[11]Using population-weighted county centroids does not lead to significant differences in county-to-county travel times because of the slow speed assigned to the "access road" network relative to other portions of the highway network.

[12]In 1960 we also include toll roads that were later incorporated into the Interstate Highway System.

a map circulated by Shell Oil Company and produced by Rand McNally in 1956 that reports both the distance and approximate travel times between points of interest and we use these to assign speeds to different road types. The 1985 map in Panel B of Figure A2 is based on the Rand McNally Atlas for 1985, which we traced from the detailed maps for each state. For 2010, we use a shapefile obtained by the National Transportation and Highway Safety Administration.[13] Panel C of Figure A2 shows the highway network in 2010.

In each year, the highway network consists of a combination of roads to which we assign different speeds based on historical sources. In our baseline highway network, we assign the actual legislated travel speeds for each class of road in the highway network (e.g., state highway, national highway, Interstate) in each year. For example, in 2010, the Interstate Highway System has a speed of 70 miles per hour, paved segments of the U.S. Highway system has a speed of 55 miles per hour, and paved state highways has a speed of 45 miles per hour. As robustness, we consider the sensitivity of our results to assigning alternative speeds to each portion of the network.

Finally, Figure A3 shows progress on the Appalachian Development Highway System in 1985 and 2010 digitized from the annual reports of the Appalachian Regional Commission. For our baseline travel time calculation we assign a speed of 55 miles per hour. Our main empirical analysis combines the network of time invariant access roads together with the highway network in each year to calculate the county-to-county travel times for all counties in the contiguous United States.[14] Ultimately, we are left with over 4 million unique pairwise

[13]Download the shapefile at `http://www.fhwa.dot.gov/planning/processes/tools/nhpn/2011/`.

[14]The time involved in so many routes is reduced by applying Dijkstra (1959)'s algorithm, which we implement using the network analyst tool in ArcGIS.

travel times, which we convert to trade costs using information on the cost of inputs for a typical freight shipment following Combes and Lafourcade (2005).

Specifically, to convert travel times to monetary costs, we use the hourly wage for a truck driver as well as the cost of diesel per mile, which is based on the cost per gallon and the number of miles traveled per gallon. Hourly wages in trucking are set equal to \$18.59 in 1960, \$19.87 in 1985, and \$18.87 in 2010 (in 2015 dollars) taken from the decennial census and the Current Population Survey. We obtain the fuel cost per mile by multiplying the miles per gallon from the Historical Statistics of the United States and US Department of Transportation with the per gallon cost of diesel from the US Department of Energy. We then combine this information to reflect the monetary cost, τ_{cdt}, of moving between any c-d county pair in year t according to:

$$\begin{aligned}\tau_{cdt} =& \text{distance in miles}_{cdt} \times \text{cost per mile}_t \\ &+ \text{travel time in hours}_{cdt} \times \text{hourly wage of truck driver}_t\end{aligned}$$

This measure of trade costs may exclude other costs (e.g., depreciation, insurance, maintenance, taxes, and tolls). Due to data availability we use labor and fuel costs, which Combes and Lafourcade (2005) find account for nearly half of total costs in French data in 1978 and 1998. The theory outlined in the next section uses the "iceberg form" of trade costs, which we obtain by dividing τ_{cdt} by the average value of a freight shipment in 2010 and adding one.

4 Theoretical Framework

We use a model of inter-regional trade to derive our main estimating equation, inform identification, and carry out counterfactual exercises. This model produces a relationship between total income and access to markets. In this context, market access provides a straightforward way to summarize the impact of a change in transportation costs *anywhere in the highway network* on total income. The model in the remainder of this section follows the exposition in Donaldson and Hornbeck (2016) and Baum-Snow, Brandt, Henderson, Turner, and Zhang (2017).

4.1 Model Setup

In the model counties are indexed by c if they are the origin of trade and d if they are the destination. Consumers have CES preferences over a continuum of differentiated goods varieties, where the elasticity of substitution between varieties is given by σ, an a local amenity denoted by A_c. Producers in each county combine a fixed factor land (L_c) and mobile factors labor (N_c) and capital (K_c) using a Cobb-Douglas technology to produce varieties. The marginal cost of each variety j is:

$$MC_c(j) = \frac{q_c^{\alpha} w_c^{\gamma} r_c^{1-\alpha-\gamma}}{z_c(j)}$$

where q_c is the land rental rate, w_c is the wage, r_c is the interest rate, and $z_c(j)$ is local productivity shifter drawn from a Fréchet distribution with CDF $F_c(z) = \exp(-T_c z^{-\theta})$. We assume that output markets are perfectly competitive.

Trade costs between c and d take the "iceberg" form: for each unit to arrive at d from c,

$\tau_{cd} \geq 1$ must be shipped. That is, if a variety is produced and sold in the same county the price is $p_{cc}(j)$, while the same variety sold in a different county has price $p_{cd}(j) = \tau_{cd} p_{cc}(j)$. In equilibrium, consumers in counties that are farther away from producers will pay higher prices and, in turn, producers that are farther away from consumers will charge lower prices. Empirically, we measure bilateral travel costs in terms of fuel costs and wages along the fastest route (in hours) between c and d.

The land available for production is assumed to be constant in each year. Capital is purchased in national, perfectly competitive markets so the returns on capital are the same in all counties with $r_c = r$. To the extent that this assumption is violated in our setting, our empirical analysis controls for state-year fixed effects to adjust for variation over time at the state level as well as additional county-level variables that capture within-state variation in geography, climate, etc. Finally, workers are perfectly mobile and reallocate across counties until nominal wages and utility (adjusted for the local price index and amenities) are equalized: $w_c = \frac{\bar{U}}{A_c} \times P_c$.

4.2 Prices and the Gravity Equation

Assuming perfect competition so that prices and marginal costs (including trade costs) are equal and letting consumers buy from the cheapest origin county, Eaton and Kortum (2002) give an expression for the price index at d:

$$P_d = \mu \sum_c \left[T_c (\tau_{cd} q_c^{\alpha} w_c^{\gamma} r_c^{1-\alpha-\gamma})^{-\theta} \right]^{-\frac{1}{\theta}}$$

with $\mu = [\Gamma(\frac{\theta+1-\sigma}{\theta})]^{\frac{1}{1-\sigma}}$, where Γ is the Gamma function. Using the assumption that $r_c = r$, Donaldson and Hornbeck (2016) define $\kappa_1 = \mu^{-\theta} r^{(1-\alpha-\gamma)\theta}$. We can then use the expression for the price index above to write:

$$P_d^{-\theta} = \kappa_1 \sum_c \left[T_c (q_c^{\alpha} w_c^{\gamma})^{-\theta} \tau_{cd}^{-\theta}\right] \tag{1}$$

which is the trade cost-weighted sum of consumers' access in d to the technology and inputs of other counties. This is referred to as "consumer market access."

Eaton and Kortum (2002) also give the following expression for the value of exports from c to d:

$$X_{cd} = \underbrace{T_c (q_c^{\alpha} w_c^{\gamma})^{-\theta}}_{\text{(i)}} \times \underbrace{Y_d \tau_{cd}^{-\theta}}_{\text{(ii)}} \times \underbrace{\kappa_1 CMA_d^{-1}}_{\text{(iii)}}$$

This expression says that trade flows from c to d are increasing in (i) local productivity of c weighted by input costs, (ii) market size of d weighted by trade costs, and (iii) competition from firms with access to d.

4.3 Total Income and Market Access

To derive a relationship between total income and market access we assume total income in c is equal to the sum of all expenditures purchased from d:

$$Y_c = \sum_d X_{cd} = \kappa_1 T_c (q_c^{\alpha} w_c^{\gamma})^{-\theta} \times \sum_d \left[\tau_{cd}^{-\theta} CMA_d^{-1} Y_d\right] \tag{2}$$

The interpretation of the final term on the right-hand side, called "firm market access," is the access of firms at c to all consumers in the economy. We define $MA_c \equiv FMA_c = \rho CMA_c$ for use in our empirical work.[15] Starting with equation (2), the next steps are to replace $\sum_d \left[\tau_{cd}^{-\theta} CMA_d^{-1} Y_d\right]$ with MA_c and substitute the income share for the immobile factor land. Then we apply the condition that real wage is equalized across locations; formally, workers move to satisfy $w_c = \frac{\bar{U}}{A_c} \times MA_c^{-1/\theta}$. Finally, we take logs and rearrange to obtain:

$$\log Y_c = \xi_c + \frac{\gamma\theta}{1+\alpha\theta} \log A_c - \frac{\gamma\theta}{1+\alpha\theta} \log \bar{U} + \frac{1+\gamma}{1+\alpha\theta} \log MA_c \tag{3}$$

where $\xi_c = \frac{1}{1+\alpha\theta} \log(\kappa_1 T_c) + \frac{\alpha\theta}{1+\alpha\theta} \log(\frac{L_c}{\alpha})$. We compute market access by solving the system of non-linear equations given by $MA_c = \rho \sum_d \tau_{cd}^{-\theta} MA_d^{-1} Y_d$.[16] Panel A of Figure 1 shows the change in the log of market access for each US county between 1960 and 2010.

Equation (3) says that income will be higher if a county has higher productivity, more land, more attractive amenities, or better market access. The increase in total income due to changes in market access may reflect firms' improved access to large markets or consumers with more access to low-cost producers. The relationship between total income and market access may also reflect effects outside of the model, for example, due to existing agglomeration economies that are reinforced by lower trade costs. In the next section, we present several approaches to alleviate concerns about endogeneity arising from unobserved factors that may

[15] With the assumption that trade costs are symmetric (i.e., $\tau_{cd} = \tau_{dc}$) the relationship between consumer and firm market access at c must satisfy $FMA_c = \rho CMA_c$.

[16] In practice, we set ρ equal to 1 when calculating the market access variable used in the empirical analysis described in the next section.

be correlated with both income and changes in trade costs.

5 Results

In this section, we discuss the results of empirical analysis motivated by the theoretical model outlined in the previous section. First, drawing on equation (3) we estimate the relationship between income and market access and use the estimated coefficient to assess the reduced-form impact of removing the ADHS. Second, using the full structure of the theoretical model, we present several counterfactuals taking into account the general equilibrium effects of alternative trade cost configurations. In particular, using the model allows us to take into account the endogenous population responses from removing or adding highway segments. We contrast the results for removing the ADHS using model-based and reduced-form approaches. We also consider several additional counterfactuals, including a smaller Appalachian highway network under an earlier plan, a more recent highway-building project around the Lower Mississippi River Valley, as well as potential extensions of the Interstate Highway System.

5.1 Empirical Analysis

To understand the impact of improvements in market access on income, as well as the specific impact of the ADHS, we start by estimating the following regression based on the relationship in equation (3):

$$\log Y_{ct} = \beta \log MA_{ct} + \phi_c + \phi_{st} + X_c \delta_t + \epsilon_{ct} \tag{4}$$

where Y_{ct} is the income in county c and year t. The main variable of interest is the log of market access, which summarizes the proximity of a county to all other markets in the United States weighted by trade costs. Again, we solve the system of non-linear equations given by $MA_c = \rho \sum_d \tau_{cd}^{-\theta} MA_d^{-1} Y_d$ to obtain our measure of market access. For the trade elasticity, θ, we assume a value of 8 in our baseline results.[17] Standard errors are clustered at the state level to allow correlation across counties in the same state over time.

In Table 1, Panel A presents the results for ordinary least squares estimates of the relationship between income and market access from equation (4). These estimates are based on using the first difference of equation (4); estimates using fixed effects are qualitatively similar and reported in the appendix. Column 1, which only controls for county and year effects, gives an estimated coefficient of 1.067. Column 2 adds state-year fixed effects and Column 3 controls for polynomials for latitude and longitude, which gives estimated coefficients of 1.298 and 1.521, respectively. The interpretation is straightforward and suggests that a 1 percent increase in market access increases income by 1 to 1.5 percent.

Following the results presented in columns 1 through 3, the main concern with our empirical approach is that the placement of the highway network is not exogenous to local productivity (or amenities). Improvements in infrastructure may be targeted to places with substantial growth potential–leading to positive bias of β–or to lagging regions–leading to

[17]This is within the range reported in the international trade literature (Head and Mayer, 2014) and close to the value of 8.22 reported in Donaldson and Hornbeck (2016), the preferred estimate in Eaton and Kortum (2002) of 8.28, and the average across 22 industries in Caliendo and Parro (2015) of 8.64.

negative bias. To address this concern we follow Donaldson and Hornbeck (2016) and use additional controls to focus variation in market access coming from non-local improvements. Column 4 adds controls for the mileage of the Interstate Highway System, Appalachian Development Highway System, and other highways as well as distance to the nearest major port, and railroad mileage in 1911 and 2010, all interacted with year fixed effects. The estimated coefficient increases to 1.375.

There is potential for market access to interact with local availability of natural resources (Black, Daniel, and Sanders, 2002; Black and Sanders, 2004, 2007; Glaeser, Kerr, and Kerr, 2015) or the sectoral specialization of employment of employment across sectors (Duranton, Morrow, and Turner, 2014). To address this issue, column 5 controls for estimated coal reserves and historical employment in manufacturing, wholesale and retail trade, transportation, construction, finance, and government, which gives a market access coefficient of 1.021.[18] Finally, in column 6, we examine whether regional income growth is driven by increasing urbanization over time (Glaeser and Gottlieb, 2008, 2009). To do this we include an indicator for whether a county belongs to a Standard Metropolitan Area, which gives an estimated coefficient of 1.049.[19]

Up to this point our identification strategy has focused on controlling for additional variables that may be correlated with the potential for income growth at the county level.

[18]Data on coal reserves is drawn from Palmer, Oman, Park, and Luppens (2015).

[19]The indicator variable for a Standard Metropolitan Area is based on an older concept related to the more recent concept of a Metropolitan Statistical Area. We use the older concept based on 1950 county characteristics, which is prior to the major highway-building projects of the second half of the twentieth century.

As alternative to this approach, we also consider an instrumental variables strategy that focuses on plausibly exogenous variation in market access. To do this we exploit variation due to the change in travel time from a given county c to all other counties. In particular, we compute the predicted average travel time from county c to all other counties using:

$$\widehat{\text{travel time}}_{ct} = \frac{1}{N_{d \notin S(c)}} \sum_{d \notin S(c)} \frac{\text{physical distance}_{cd}}{\text{average speed}_{cdt}} \tag{5}$$

This variable focuses on changes in travel time due to connections between counties not in the same state. In particular, the instrument exploits non-local highway improvements that translate into increased average speed holding the straight-line distance between two locations constant. Importantly, we use no information on market size to construct the instrument since the relocation of economic activity (or population) may be endogenous. We also exclude counties within the same state because highway construction decisions were administered at the state level.[20] We use the first-difference of equation (5) to instrument for the first-difference of market access in our main estimating equation.

To satisfy the criteria for a valid instrument the variable in equation (5) must be correlated with market access and be uncorrelated with the error term in equation (4). For the first-stage relationship, a county with a higher average travel time will have lower market access. Indeed, consistent with this intuition the estimated first-stage coefficient is -1.699 and the first-stage F-statistic is 95.73. For the exclusion restriction, the theory suggests that endogeneity may arise due to a correlation between change in market access and unob-

[20] Even national plans, such as the Interstate Highway System, were routed (i.e., purchase of rights of way), constructed, and maintained by state highway departments.

served productivity growth. Although we cannot directly test this assumption, Figure A4 presents a placebo test showing no significant relationship between changes in the instrument, $\widehat{\text{travel time}}_{ct}$, and a potential correlate of productivity growth (i.e., historical population growth).[21] In Panel A of Table 1, column 7 gives the estimated coefficient on market access using our instrumental variable strategy. The estimate of 0.656 is smaller than coefficients reported in columns 1 through 6, which suggests that at the national level infrastructure improvements were targeted at high income or high growth potential regions. From equation (3), the coefficient on market access is equal to $\frac{1+\gamma}{1+\alpha\theta}$. If we calibrate the α and γ with our preferred values from Caselli and Coleman (2001) of 0.19 and 0.60, respectively, and solve for θ we obtain a value of 7.5. This is close to our assumed value for θ of 8.[22]

Finally, given our focus on Appalachia, before moving on to discuss our counterfactual results we examine whether the response to changes in market access is different between ARC and non-ARC counties. In particular the market access coefficient may not be uniform across regions in the United States, which would not be consistent with the theory and has important implications for understanding the impact of removing or augmenting transportation infrastructure in and around the region. To examine this possibility, we include an

[21]The estimated slope coefficient for the relationship shown in Figure A4 is 0.023 (s.e. = 0.023) for the left panel and -0.062 (s.e. = 0.051) for the right panel.

[22]The relationship between the log of population and market access predicted by the model is given by: $\log N_c = \xi_c + \frac{1+\theta(\alpha+\gamma)}{1+\alpha\theta}[\log \bar{U} - \log A_c] + \frac{1+\theta(1+\alpha+\gamma)}{\theta(1+\alpha\theta)} \log MA_c$. Replacing the outcome variable with the log of population and reestimating equation (3) gives an estimated coefficient on market access of 0.65. Again, solving for the implied value of θ we obtain a value of approximately 10.

interaction between the log of market access and an indicator for whether a county belonged to the Appalachian Regional Commission (i.e., $\log MA_{ct} \times \text{ARC}$) in equation (4). The results using instrumental variables are reported in column 1 of Table A3 in the online appendix; the estimated coefficient on the interaction is small and statistically insignificant.

While there is no significant difference in the estimated coefficients between income and market access across ARC and non-ARC counties, there may be changes in other outcomes that reflect changes in long-run trends in regional specialization from improvements in transportation. Columns 2 through 7 of Table A3 show results replacing the outcome variable with employment in manufacturing, wholesale and retail trade, transportation, construction, finance, and government. Except for manufacturing, which decreases in ARC counties relative to the rest of the country, employment in other sectors shows no differential response inside and outside of Appalachia.

Overall, our results so far suggest that our theoretical approach is reasonable. The estimated coefficient on market access implies a plausible range of values for the trade elasticity, θ. Next, we turn to our counterfactual results, which focus on aggregate impacts and effects on the spatial distribution of economic activity from removing highways built as part of the Appalachian Regional Commission. In the final sub-section, we examine the sensitivity of our counterfactuals.

5.2 Counterfactuals

To understand the aggregate impact of changes in the highway network, our first approach is to use the estimated coefficients on market access from Panel A of Table 1 together with counterfactual changes in market access to evaluate the effect of changes in the highway network. In particular, in the case of the Appalachian Development Highway System, Panel B of Figure 1 shows the difference between actual market access and counterfactual market access in 2010 after removing the ADHS from the highway network and recomputing trade costs. Importantly, removing the ADHS reduces market access both inside and outside of the ARC program area. Thus, some of the gains associated with the ADHS spillover to counties that were not initially targeted, although the benefits are still quite regionally concentrated.

To quantify the aggregate impact of this change, we take the coefficients estimated in Panel A multiplied by the losses depicted in Figure 1B and then sum over all counties. The results of this exercise are shown in Panel C of Table 1, which gives counterfactual losses between \$58 and \$88 billion (in 2015 dollars) using ordinary least squares or \$36 billion using instrument variables. This approach fixes income in year t so that national income and its spatial distribution across counties do not change in response to counterfactual changes in trade costs. That is, the estimated aggregate impacts do not allow for endogenous changes in market size with the reduction in trade costs.

The second approach we use exploits the structure of the model outlined in Section 4. The equilibrium in each year is given by the following system of equations:

$$\begin{aligned}
MA_c &= \rho \sum_d \tau_{cd}^{-\theta} MA_d^{-1} Y_d \\
\log Y_c &= \xi_c + \frac{\gamma\theta}{1+\alpha\theta} \log A_c - \frac{\gamma\theta}{1+\alpha\theta} \log U + \frac{1+\gamma}{1+\alpha\theta} \log MA_c \\
\bar{U} &= \frac{\gamma A_c Y_c}{N_c} MA_c^{\frac{1}{\theta}} \\
\bar{N} &= \sum_c N_c
\end{aligned}$$

which describes the relationship between market access, total income, and population holding fixed local productivities, amenities, utility, and total population ($\bar{N}$).[23] Using assumed values for the land share of income, labor share of income, and trade elasticity, as well as information on actual trade costs, total income, and population, we can solve the above system of equations for equilibrium values of ξ_c, A_c, and MA_c. Then, using the equilibrium values of ξ_c and A_c combined with counterfactual trade costs, we can solve for the counterfactual income and population for different two scenarios.

To start, we ask: what is the change in income and population associated with removing the ADHS and fixing utility? This captures the idea that because counterfactual trade costs are higher after removing the ADHS, income and population need to fall in order for utility to be constant. As a benchmark, we begin by using a value of θ equal to 8 and α and γ equal to 0.19 and 0.60, respectively.[24] In the first row of Table 2, column 1 reports a \$53.7 billion loss in income or 0.40 percentage points of total income in column 2 from removing the ADHS in 2010. This number captures the loss of income due to allowing people to leave the economy aggregated across all US counties and also reflects the importance of allowing for reallocation across space in response to changes in trade costs.[25] Column 3 in the first

[23]We suppress the t subscript to simplify notation and note the corresponding year for each counterfactual.

[24]The values of α, γ, and θ are drawn from the literature. We start with a value of θ that is close to estimates reported in Donaldson and Hornbeck (2016), Eaton and Kortum (2002), and Caliendo and Parro (2015) in different contexts. For α and γ we use draw on Caselli and Coleman (2001). After presenting our main counterfactual results we consider the sensitivity of the results to alternative parameters values in Section 5.3.

[25]Instead, if we follow the "social savings" approach commonly used in economic history

row of Table 2 shows the corresponding absolute (1.64 million) and percentage point (0.53) decrease in population in 2010.

Alternatively, we can also use the model to ask: what is the decline in utility required to satisfy the equilibrium system of equations holding population fixed? This captures the idea that because population cannot decrease, utility must fall to account for the higher costs of trading. In this case, the final column in the first row of Table 2 gives a decrease in utility of 0.13 percentage points. This 0.13 percentage point decrease in utility comes in the context of a complete migration response that best reflects "long-run" adjustments in population. Focusing on the "short-run" case without population adjustments, we calculate a 0.24 percentage point decrease in utility. This suggests an important role for migration in responding to changes in trade costs.

Moving back to the "long-run" case, we can also examine changes in total income and population between ARC and non-ARC counties. That is, holding population constant, there may still be movement of income and people *between* regions in response to the counterfactual change in trade costs. Indeed, for 2010, we find that income and population in ARC counties would have decreased by $19.13 billion and 618,821, respectively, in the absence of the ADHS.

(Fogel, 1964; Leunig, 2010), we estimate losses between 0.06 and 0.07 percentage points of income. To do this calculation, we compute the average price of shipping one ton of freight by truck across all routes using the actual highway network in 2010 and the counterfactual highway network in 2010 after removing the ADHS. We then multiply the difference in average prices under the scenarios by the total number of tons shipped and divide by income. In the context of our model, we also calculate that the average increase in the price index across all counties from removing the ADHS would have been 0.11 percentage points.

The decrease in income is nearly compensated by an increase of income in non-ARC counties of \$18.48 billion, while the decrease in population in ARC counties is exactly offset of by an increase in non-ARC counties by assumption.

These two scenarios (i.e., fixing utility or fixing population) represent two paths for how the economy might adjust to counterfactual changes in trade costs. In the first scenario, worker utility is constant and so the margin of adjustment is a decrease in population; in the second scenario, the total US population is constant and so utility must fall. In particular, the similarity of the estimated coefficients on market access when income and population are used as outcome variables suggests that population will be highly mobile in the face of new economic circumstances brought about by higher trade costs, rather than suffering the decline in utility that would come from remaining in place with fewer trading opportunities. For this reason, in the remainder of the paper, we focus on the first scenario in which worker utility is fixed.

As highlighted by Figure 1B, the losses associated with removing the ADHS are not restricted to counties targeted by the ARC. To quantify the effect on the spatial distribution of economic activity, rows 2 and 3 of Table 3 report the loss income for counties inside and outside of the Appalachian Regional Commission, holding utility constant. In this case, the loss to counties included in the ARC would have \$21.83 billion compared with \$31.83 billion for counties outside the ARC. Interestingly, this suggests that less than half of the benefits of the ADHS accrued to counties initially targeted by the policy and, thus, leakage to non-targeted counties was substantial. Figure 2 shows changes in the actual share of total income in ARC counties and the counterfactual share after removing the ADHS. In 1960 the actual and counterfactual shares are the same and afterward the shares diverge to reflect the gains in economic activity within the region stemming from lower trade costs. In the absence of the ADHS, the share of income in the ARC decreased to 6.7 percent. This suggests that better highways offset about 11.1 percent of the potential decline, but also that more of the decline could have been mitigated in the absence of spatial leakage.

As an alternative to simply removing the ADHS, we consider the effect of removing the ADHS and replacing it with alternative highways.[26] We start by replacing the 2,500-plus mile highway network actually built with the smaller system initially planned under the President's Appalachian Regional Commission (PARC). The PARC plan was approximately 1,000 miles smaller than the ADHS and the difference in mileage between the two systems arose from political concessions that were necessary to pass the enabling legislation. For example, Senator Robert Kennedy added an amendment to include several New York counties in the ARC.[27] In 1973, Corridor V in Alabama and Mississippi was approved with additional appropriations provided by Congress in 1969 and 1971. Following the re-authorization of the ARC in 1976, Corridor X in Alabama and Mississippi was approved for construction.[28] As reported in the second row of Table 3, replacing the ADHS with the PARC plan high-

[26]The appendix provides maps showing the location of each of the project we examine below.

[27]This paved the way for the construction of Corridor T between Binghamton, NY, and Erie, PA, and Corridor U between Elmira, NY, and Williamsport, PA, which added approximately 280 miles to the ADHS.

[28]Combined the construction of Corridors V, X, and X-1 in Alabama and Mississippi added more than 400 miles, despite Alabama being purposefully excluded from the initial plan due to substantial coverage within the Interstate Highway System.

ways gives income losses of \$25.2 billion (or 0.19 percent of income). This suggests that the mileage added to the plan as part of political bargaining was not too costly.

Next, we turn to other regionally targeted highways to assess the efficacy of the ADHS against proposals under ongoing consideration. In 2000, the Delta Regional Authority (DRA) was established under the Clinton administration to aid distressed counties in the Lower Mississippi River Valley. The DRA is a partnership between federal, state, and local governments as well as business, with many features similar to the ARC.[29] The DRA provides a special designation for 252 counties in Alabama, Arkansas, Illinois, Kentucky, Louisiana Mississippi, Missouri, and Tennessee, such as lower local matching requirements and a large focus on infrastructure investment. A key goal is to upgrade highways and intermodal transportation, spearheaded by the Delta Development Highway System (DDHS). The proposed (and not built as of 2010) highways total roughly 3,800 miles focused on upgrading to limited-access highways, higher speeds, and more lanes. The third row of Table 3 shows the income loss from replacing the ADHS with the DDHS gives income losses of \$25.6 billion (or 0.19 percent of income). The smaller effect is driven by the higher density of the Interstate Highway System in the region as well as the lower incomes in the surrounding area. That is, the ADHS connects Appalachia to the productive regions of the East Coast and Upper Midwest, whereas the DDHS provides links within the Southeast and between the relatively poorer surrounding areas to the Southwest and Lower Midwest.

Finally, as an alternative to building regional highway systems, there are also proposals

[29] The funding was initially proposed as an addition to the ARC, but a separate authority was ultimately created due to concerns that this step would dilute funding to the ARC.

to extend the Interstate Highway System. We consider three segments that are "high priority corridors designated as future Interstates" by the Federal Highway Administration: I-9 in California's Central Valley along California State Route 99, I-11 between Phoenix, AZ, and Reno, NV, and I-69 between South Texas and Indianapolis. These corridors are interesting alternatives to the ADHS because they do not intersect counties or states covered by the ARC and augment a national rather than regional highway system. The fourth and fifth rows of Table 3 still show substantial losses from removing the ADHS and adding either I-9 ($25.9 billion) or I-11 ($26.0 billion). In both cases, the new segments have close existing substitutes and would only modestly increase graded speeds. In contrast, the sixth row of Table 3 shows that the completion of I-69 would offset nearly two-thirds of the losses of the ADHS. This suggests that substantial gains may be possible from constructing large arterial highways that connect major cities and border crossings.

Taken together, our findings point to three main conclusions. First, in the second half of the twentieth century, the gains from the Appalachian Development Highway were larger than other proposals for regionally-targeted highway construction or upgrading; removing the ADHS and replacing it with any one of PARC, DDHS, I-9, or I-11 would have mitigated less than half of the losses. At the aggregate level, the closest substitute to the ADHS is I-69 and completing the mostly unfinished route would have offset roughly two-thirds of the losses. Second, there was substantial leakage outside of the area targeted by ADHS: over half the benefits accrued to counties outside of the ARC. Ultimately, this suggests it may be difficult to achieve the spatially-targeted goals of many placed-based policies. Third, comparing the results to Donaldson and Hornbeck (2016) for railroads in the nineteenth century United States, Alder (2017) for highways in India, and Allen and Arkolakis (2014) for the Interstate Highway System, our results suggest the effects of the ADHS were modest relative to national infrastructure projects.

5.3 Robustness

The results in the previous sub-section depend on several assumptions. First, the model-based counterfactuals assume values of α, γ, and θ. The literature reports a range of values for θ (Head and Mayer, 2014) and α (Valentinyi and Herrendorf, 2008). As robustness, in Figure 3 we consider what counterfactual losses would be from removing the ADHS in 2010 for different values of α or θ and fixing γ at 0.60. In the extreme cases, losses from removing the ADHS decrease to less than \$40 billion ($\theta = 18$, $\alpha = 0.19$) and increase to roughly \$125 billion ($\theta = 6$, $\alpha = 0.05$). Focusing on parameter values typically used in the literature, the range of losses represents less than a percentage point of aggregate income in 2010.

Second, to calculate market access we used only information on domestic market size, which does not account for the potential role of international trade. Following Donaldson and Hornbeck (2016), we use international imports and exports to inflate the income of each county with a major international port-of-entry. We then recompute the loss associated with removing the ADHS, which is equal to \$61 billion.

Third, to calculate trade costs we assumed actual legislated travel speeds for each class of road in the highway network (e.g., state highway, national highway, Interstate) in each year. This approach combines the growth in the overall network with the increase in speed due better roads graded for higher speeds that also occurred over the sample period. As robustness, we assign alternative speeds to each type of road. First, we fix the speed on each type of road as they were in 1960 to focus primarily on the growth in the highway network over time. In this case, the income loss associated with removing the ADHS is \$65.5 in 2010. Second, because some segments of the ADHS have been incorporated into the Interstate Highway System (e.g., I-22, I-68, and I-86), we also consider increasing the speed on the ADHS. In this case, the income loss from removing the ADHS is \$70.7 billion in 2010. These losses are similar to but higher than the \$53.7 billion estimated in the baseline scenario in Section 5.2.

Finally, in our main results each county was represented as a point in space based on its geographic centroids. One concern is that it may place the center of activity far away from population centers where highways are more likely to be routed. This problem may be particularly problematic in Western states and areas with rugged terrain. To address this concern, we in recalculated trade costs using the 2010 population centroids as reported by the Census Bureau.[30] Using the population weighted centroids, we estimate that income losses due to removal of the ADHS would have been \$51.0 billion in 2010.

6 Conclusion

In 1965 President Johnson signed legislation creating the Appalachian Regional Commission, which aimed to reduce poverty in isolated pockets of West Virginia, Kentucky, and the surrounding states. Central to the Commission's approach to improving economic conditions in the region was the construction of high quality highways to complement the Interstate Highway System. Between 1965 and 2010 over 2,500 highway miles called the Appalachian

[30] The 2010 population centroids are available and can be downloaded at the Census Bureau website: https://www.census.gov/geo/reference/centersofpop.html.

Development Highway System (ADHS) were built. As a result, over the last five decades Appalachia experienced a substantial decline in transportation costs.

In this paper, we use a model of interregional trade together with newly digitized data of the Appalachian, Interstate, US, and state highway systems in 1960, 1985, and 2010 to examine the impact of the ADHS on regional development. We quantify the impact of the fall in trade costs associated on the region and find aggregate gains of $54 billion, or about 0.4 percent of national income, due to the ADHS. Roughly half of the losses are concentrated in the counties designated by the Appalachian Regional Commission, which suggests substantial leakage outside of the region directly targeted by the ADHS. We also find that the region's share of national income would have been 11 percent lower in the absence of the ADHS. Thus, in the absence of the ADHS, more economic activity (and people) would have left the region over the 50 years that we consider. Ultimately, the gains stemming from the highway-building were not enough to overcome more fundamental changes in Appalachia.

These findings contribute to an ongoing debate in urban and regional economics regarding the impact of transportation infrastructure. In this paper, we are the first to address the transportation portions of federal government spending on regional development in the second half of the twentieth century. Moreover, the results are useful for understanding the long-run implications of place-based policies in underdeveloped regions in the United States and provide a starting point for further research evaluating the efficacy of ongoing policies.

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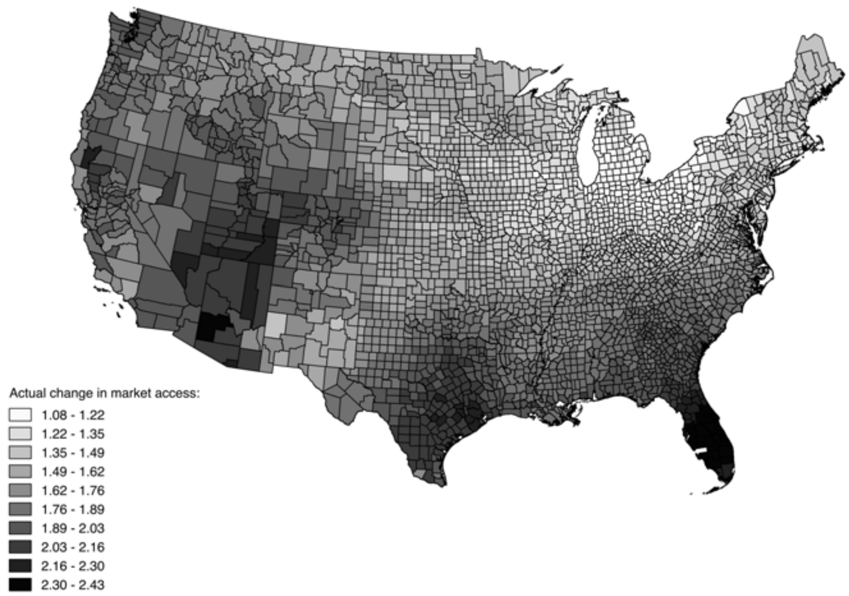
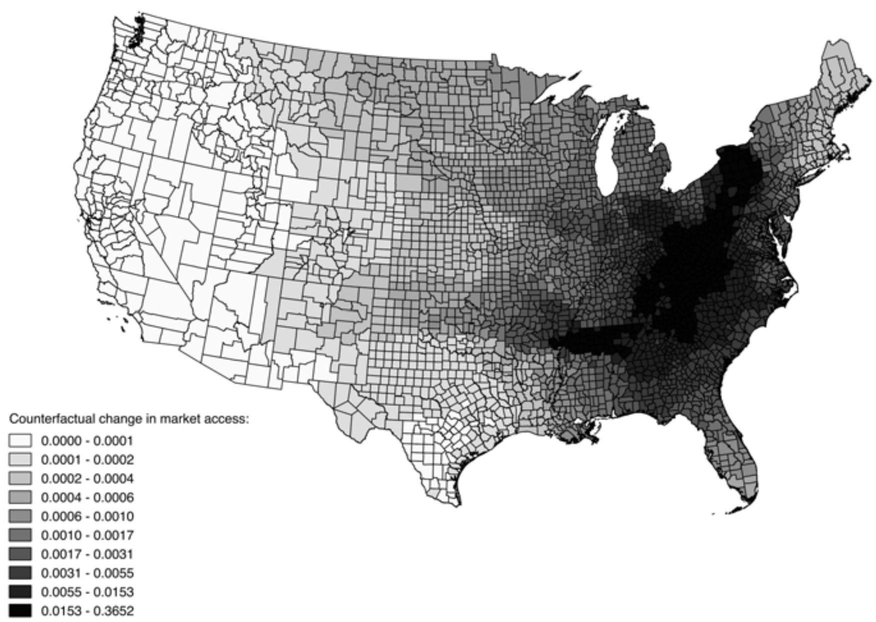
Figure 1: Change in Market Access in US Counties, 1960-2010



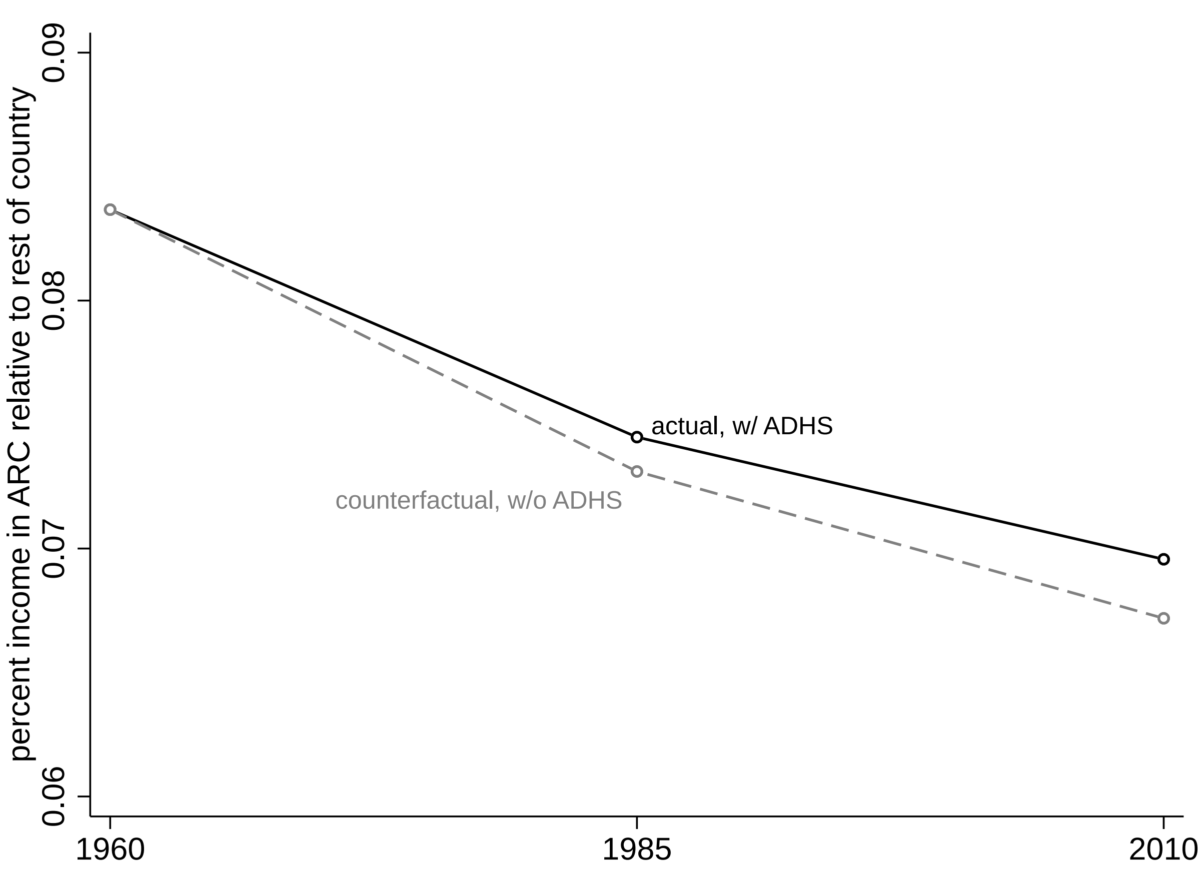
A. Actual Change in Market Access, 1960-2010



B. Counterfactual Change in Market Access without ADHS, 2010

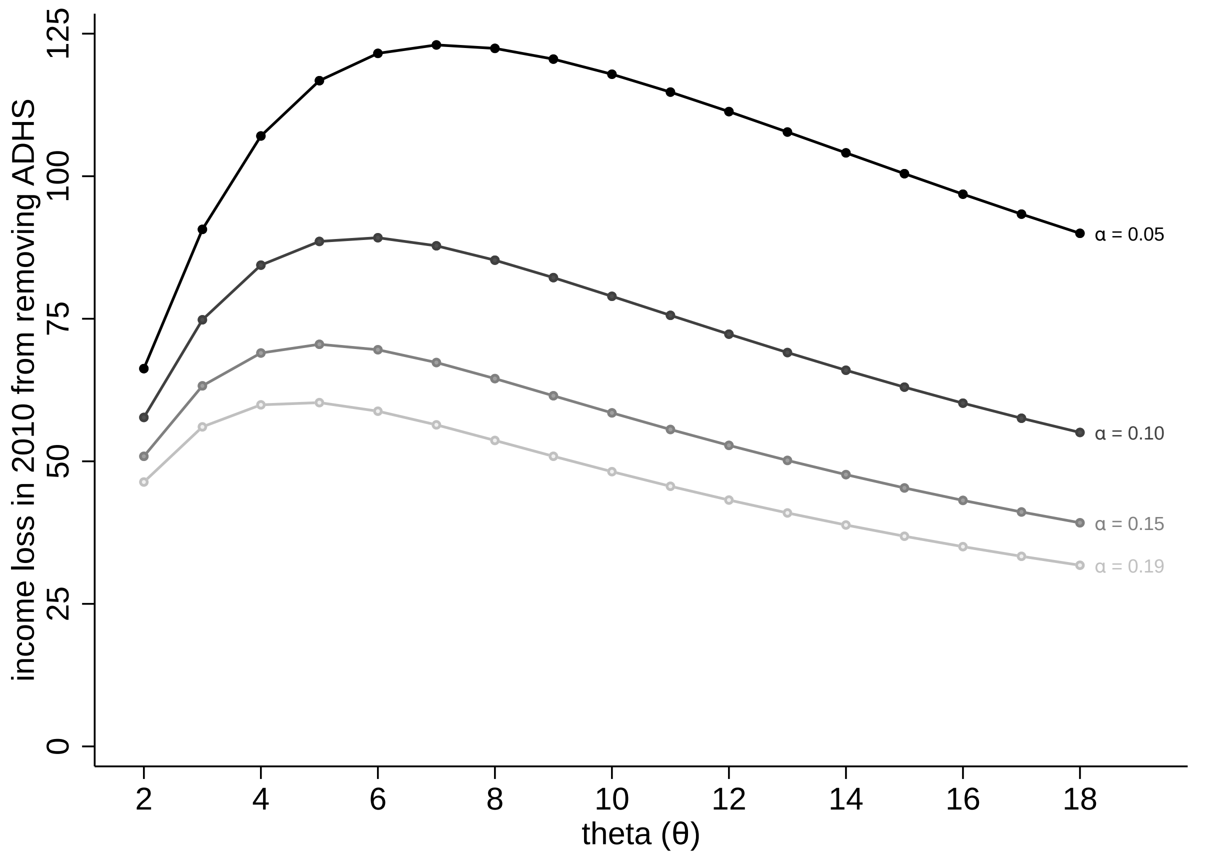
Notes: Panel A shows the difference between the log of market access in 2010 and 1960 for all US counties. Panel B shows the difference between the log of actual and counterfactual market access in the absence of the ADHS in 2010 for all US counties.

Figure 2: Actual and Counterfactual Share of Income in ARC and Non-ARC Counties



Notes: The figure shows the actual (solid line) and counterfactual (dashed line) share of income in ARC and non-ARC counties between 1960 and 2010.

Figure 3: Counterfactual Results with Alternative Parameter Values



Notes: The figure shows counterfactual results using alternative values of α and θ the value of γ fixed at 0.60.

Table 1: Relationship between Market Access and Income

	Ordinary Least Squares						IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: ordinary least squares and second stage instrumental variables							
dependent variable is log of income							
log(market access)	1.067	1.298	1.521	1.375	1.021	1.049	0.656
	(0.064)	(0.153)	(0.165)	(0.160)	(0.173)	(0.170)	(0.314)
Panel B: first stage instrumental variables							
dependent variable is log of market access							
log($\widehat{\text{travel time}}$)							-1.699
							(0.174)
First Stage F-statistic							95.73
Panel C: counterfactuals losses from removing the ADHS in 2010							
counterfactual loss (in billions)	60.7	74.4	87.8	79.0	58.0	59.7	36.8
	(3.8)	(9.1)	(10.0)	(9.6)	(10.2)	(10.0)	(18.0)
Included control variables (interacted with year effects in column 3 through 6):							
year fixed effects	yes	yes	yes	yes	yes	yes	yes
state-year fixed effects	no	yes	yes	yes	yes	yes	yes
polynomial in lat. and long.	no	no	yes	yes	yes	yes	yes
highway mileage	no	no	no	yes	yes	yes	yes
coal, sectoral employment	no	no	no	no	yes	yes	yes
standard metropolitan area	no	no	no	no	no	yes	yes

Notes: The table shows the results from estimating equation (4) in first differences with the log of income as the dependent variable. Panel A presents the estimated coefficient on market access. Column 1 includes year fixed effects and column 2 includes state-year fixed effects. Column 3 adds controls polynomials in latitude and longitude and the log of county area (interacted with year fixed effects). Column 4 adds controls for the mileage of the Interstate Highway System, Appalachian Development Highway System, and other highways, as well as distance to the nearest major port, and railroad mileage in 1911 and 2010 (interacted with year fixed effects). Column 5 adds coal reserves and historical employment by sector (interacted with year fixed effects); column 6 adds an indicator for the Standard Metropolitan Area (interacted with year fixed effects). Column 7 gives the second-stage coefficient on market access using instrumental variables and including all controls. Panel B presents the first stage coefficient and first stage F-statistic from using instrumental variables. Panel C presents the counterfactuals losses in income from applying the estimated coefficient in Panel A to the change in market access from removing the ADHS shown in Figure **??**. Standard errors reported in parentheses are clustered at the state-level. The number of sample counties in each year is 3,080.

Table 2: Counterfactuals Losses from Removing the ADHS in 2010

	holding $\bar{U}$ fixed				holding $\bar{N}$ fixed
	income loss in billions (1)	percent of total (2)	population loss in millions (3)	percent of total (4)	percent utility decline (5)
1. All Counties	53.66	0.40	1.64	0.53	0.13
2. ARC	21.83	0.16	0.74	0.24	
3. Non-ARC	31.83	0.24	0.90	0.29	

Notes: This figure shows counterfactual income losses in 2010 from removing the ADHS for all counties (row 1) and separately for ARC (row 2) and non-ARC (row 3) counties. Column 1 gives the income loss (in billions) in 2015 dollars and column 2 gives the income loss as a share of US total income, holding utility fixed; column 3 gives the population loss (in millions) and column 4 gives the population loss as a share of US population, holding utility fixed. Column 5 gives the percent decline in utility holding population fixed.

Table 3: Counterfactuals Losses from Replacing the ADHS with Alternative Highways

	income loss in 2010:	
	2015 dollars in billions	percent of US total
	(1)	(2)
Remove		
1. ADHS	53.66	0.40
Replace with		
2. PARC	25.20	0.19
3. Delta Regional Authority	25.58	0.19
4. I-9	25.92	0.19
5. I-11	26.03	0.19
6. I-69	15.13	0.11

Notes: This figure shows counterfactual income losses in 2010 from removing the ADHS (row 1) and replacing the ADHS with PARC (row 2), Delta Regional Authority highways (row 3), and I-9 (row 4), I-11 (row 5), and I-69 (row 6). Column 1 gives the income loss in 2010 in 2015 dollars and column 2 gives the income loss as a share of US total income.

A Online Appendix for "National Policy for Regional Development"

Table A1: Summary Statistics for Income, Population, and Market Access

	All Counties (1)	ARC Counties (2)
A. 1960		
labor income (in millions)	862.5	516.6
	(3,872.3)	(1,531.3)
population (in thousands)	58.2	44.9
	(205.0)	(97.7)
market access	84,224.2	130,743.3
	(70,263.0)	(57,430.6)
B. 1985		
labor income (in millions)	2,481.6	1,334.8
	(9,317.0)	(2,975.5)
population (in thousands)	76.7	51.4
	(252.0)	(91.0)
market access	292,820.3	448,457.9
	(191,166.5)	(132,519.9)
C. 2010		
labor income (in millions)	4,362.8	2,201.5
	(15,267.4)	(4,430.0)
population (in thousands)	99.8	60.7
	(316.1)	(98.6)
market access	378,367.8	564,713.0
	(248,617.4)	(159,765.5)

Notes: The table shows mean and standard deviation (in parentheses) for income, population, market access in 1960, 1985, and 2010 for all sample counties in column 1)and counties in the Appalachian Regional Commission in column 2. The number of sample counties in each year is 3,080.

Table A2: The Relationship Between Market Access and Income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: ordinary least squares and second stage instrumental variables							
dependent variable is log of income, independent variable is log of market access							
market access	1.051	1.453	1.702	1.645	1.290	1.306	0.832
	(0.059)	(0.183)	(0.214)	(0.176)	(0.187)	(0.185)	(0.279)
Panel B: first stage instrumental variables							
dependent variable is log of market access, independent variable is log of predicted travel time							
$\widehat{\text{travel time}}$							-1.839
							(0.186)
First Stage F-stat							98.04
Panel C: counterfactuals losses from removing the ADHS in 2010							
counterfactual loss (in billions)	59.7	83.7	98.9	95.3	73.9	74.8	59.5
	(3.5)	(11.1)	(13.1)	(10.7)	(11.2)	(11.1)	(20.8)

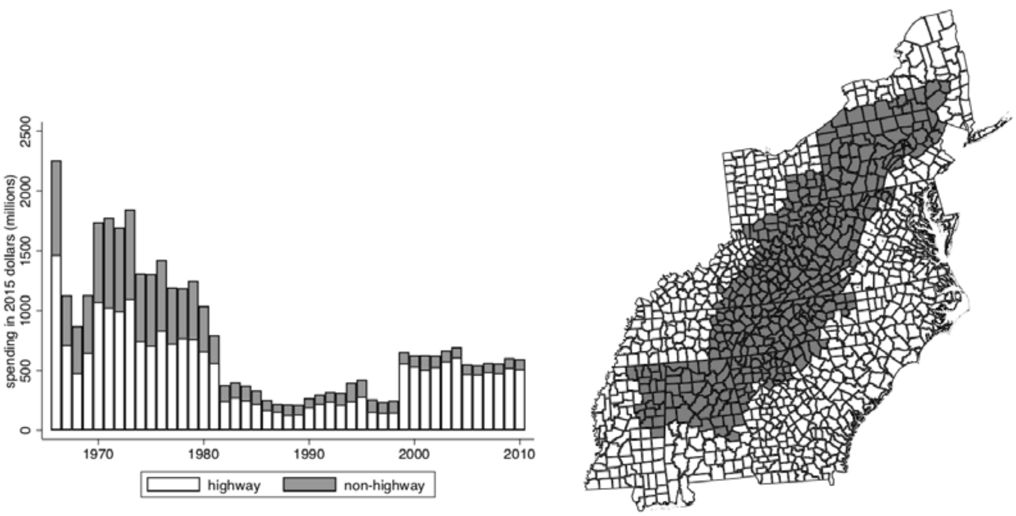
Notes: The table shows the results from estimating equation (4) using fixed effects with the log of income as the dependent variable. Panel A presents the estimated coefficient on market access. Column 1 includes year fixed effects and column 2 includes state-year fixed effects. Column 3 adds controls polynomials in latitude and longitude and the log of county area (interacted with year fixed effects). Standard errors (in parentheses) are clustered at the state level. Column 4 adds controls for the mileage of the Interstate Highway System, Appalachian Development Highway System, and other highways, as well as distance to the nearest major port, and railroad mileage in 1911 and 2010 (interacted with year fixed effects). Column 5 adds coal reserves and historical employment by sector (interacted with year fixed effects); column 6 adds an indicator for the Standard Metropolitan Area (interacted with year fixed effects). Column 7 gives the second-stage coefficient on market access using instrumental variables and including all controls. Panel B presents the first stage coefficient and first stage F-statistic from using instrumental variables. Panel C presents the counterfactuals losses in income from applying the estimated coefficient in Panel A to the change in market access from removing the ADHS shown in Figure **??**. Standard errors reported in parentheses are clustered at the state-level. The number of sample counties used is 3,080.

Table A3: Relationship between Market Access and Income or Employment by Region

	Income	Employment by Sector					
		Mfg.	Trade	Trans.	Con.	Fin.	Gov.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
dependent variable is log of income or employment by sector							
log(market access)	0.675	1.251	1.538	1.606	1.433	1.534	1.485
	(0.315)	(0.596)	(0.365)	(0.534)	(0.410)	(0.605)	(0.530)
log(market access) × ARC	-0.032	-0.093	-0.019	-0.001	-0.009	-0.029	0.010
	(0.040)	(0.043)	(0.030)	(0.049)	(0.044)	(0.046)	(0.035)

Notes: The table shows the results from estimating equation (4) using instrumental variables with the log of income (column 1) or employment by the sector manufacturing (column 2), wholesale and retail trade (column 3), transportation (column 4), construction (column 5), finance and related industries (column 6), and government (column 7) as the outcome variable. Standard errors reported in parentheses are clustered at the state-level. The number of sample counties in each year is 3,080.

Figure A1: Appalachian Regional Commission Program Area and Spending

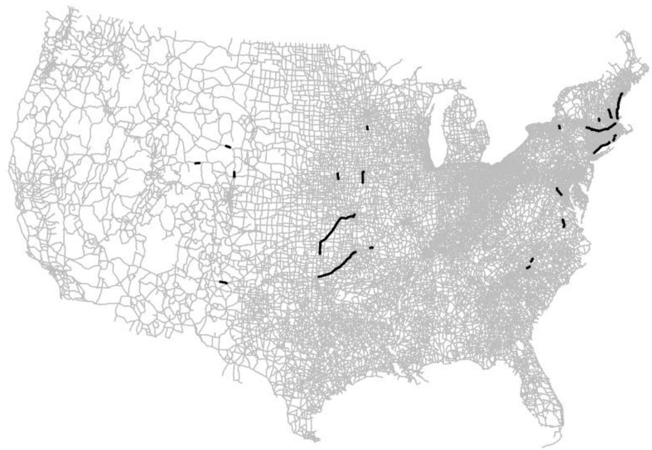


A. Program Area

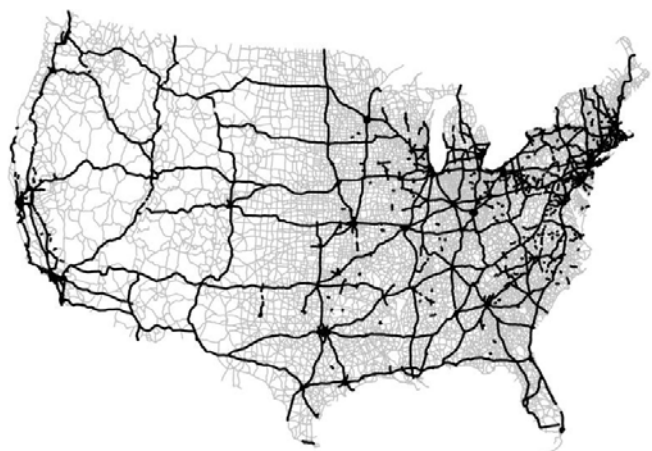
B. Aggregate Spending

Notes: Panel A shows the counties included in the Appalachian Regional Commission. Panel B shows aggregate spending by the Appalachian Regional Commission in 2015 dollars separately by the highway (unshaded) and non-highway (shaded) components from 1965 to 2010.

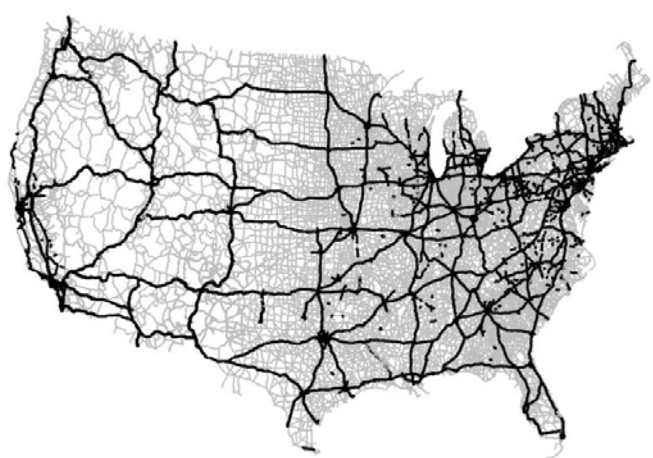
Figure A2: US Highways in 1960, 1985, and 2010



A. 1960



B. 1985



C. 2010

Notes: The figure shows growth of the highway network between 1960 and 2010. In each panel the solid black lines show progress on the Interstate Highway System in a given year and the gray lines show the other portions of the highway network.

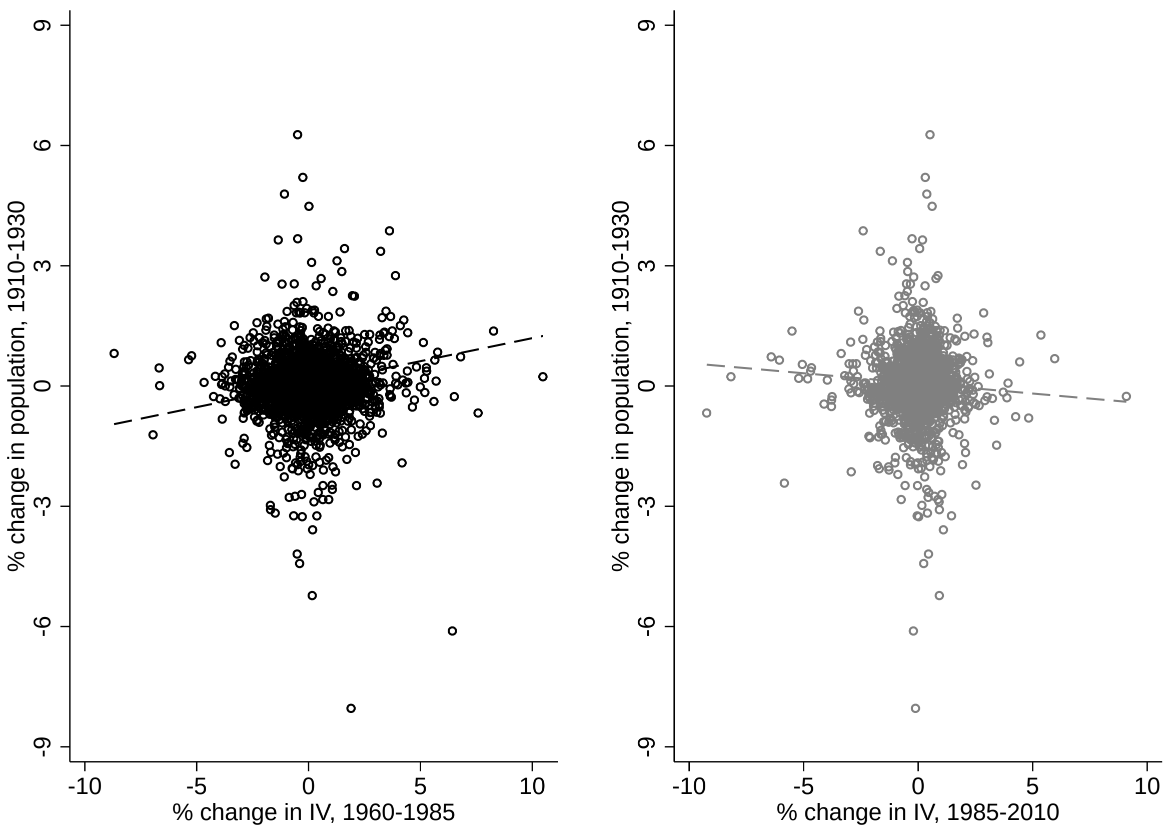
Figure A3: Appalachian Development Highway System in 1985 and 2010

A. 1985

B. 2010

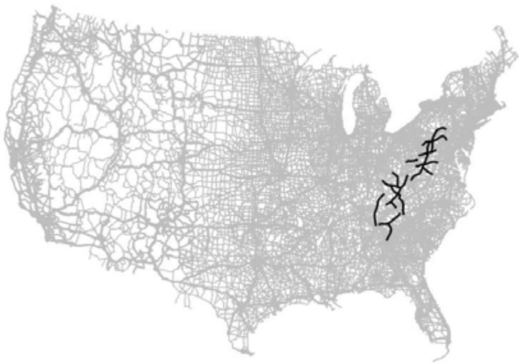
Notes: The figure shows the Appalachian Development Highway System in 1985 and 2010. In each panel the solid black lines highlight the ADHS and gray lines show the remaining portions of the network.

Figure A4: Placebo for Instrumental Variables Approach

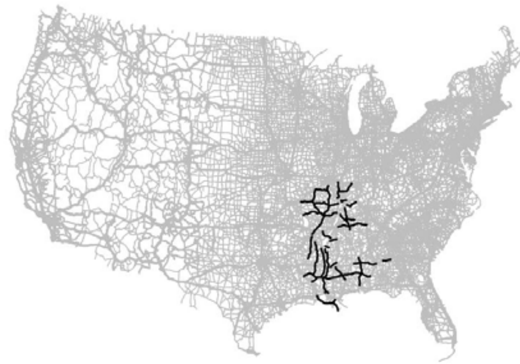


Notes: This figure shows the relationship between population growth from 1910 to 1930 and the change in instrumental variable in equation (5) from 1960 to 1985 in the left panel and from 1985 to 2010 in the right panel. The estimated slope coefficients for the relationship are 0.023 (s.e. = 0.023) for the left panel and -0.062 (s.e. = 0.051), respectively, in the left and right panels.

Figure A5: US Highways in 1960, 1985, and 2010

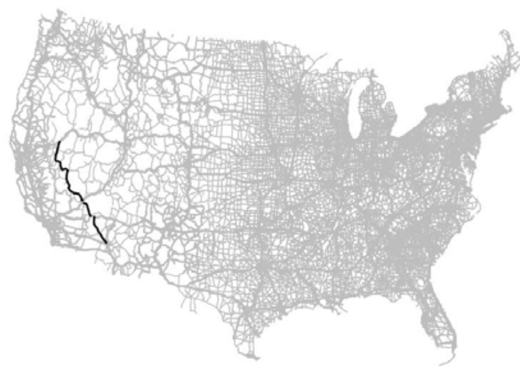


A. PARC

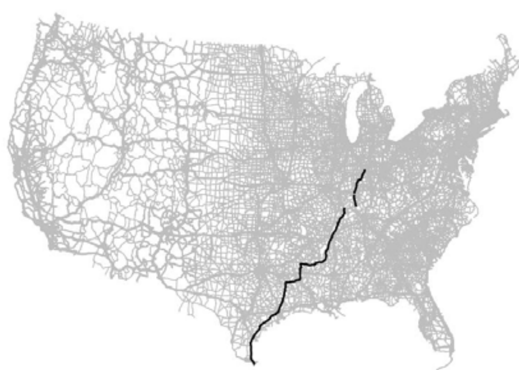


B. Delta Regional Authority

C. I-9



D. I-11



E. I-69

Notes: The figure shows the location of alternative highway-building proposals that we consider as counterfactuals in the main text.