Using legislation known as “map acts,” a number of states plan for highway construction by announcing without warning that certain properties fall within “designated highway corridors.” Map acts save money for the state because they freeze affected property owners’ right to upgrade their property for a given length of time, which lowers the state’s acquisition costs. Until mid-2016, North Carolina had no legislative deadlines for future road completion, leaving thousands of homeowners in limbo for long lengths of time in dozens of projects around the state. This study uses a natural experiment to measure the effect of legislative uncertainty on property values. Evidence was gathered in Forsyth County, NC, using a dataset of 16,817 homes. Our cross-sectional study compares property values of those homes that lie within a long-delayed road corridor with the values of those directly adjacent to it. The regression results indicate that homes within the Forsyth County road corridor suffer the unintended consequences of map acts, with statistically significant and large drops in their assessed property values. Adjacent homes suffer smaller losses. In total, Forsyth County has lost an estimated $57 million in assessed property value as a result of this one road corridor, having repercussions on the local tax base. Other factors such as proximity to nearby amenities and state ownership of affected corridor properties were also found to be statistically significant.

**KEYWORDS:**
local development; planning; property rights, transportation corridors, takings (eminent domain)
I. INTRODUCTION

State governments face an ongoing and expensive task of building new roads and highways. A natural tension exists between lowering state budgetary pressures and maintaining individual property rights. Legislative “map acts” limit or forbid property owners in designated road corridors from improving the value of their land or dwelling, potentially saving the state millions of dollars when it comes time to build the road. By 2015, thirteen states were using map acts when planning roads (Richardson 2017). A key point is that unlike what happens with eminent domain, property owners who fall under map-act-designated corridors lose a portion of their property rights without compensation since they are typically forbidden to upgrade or develop their property for a stated period of time.

As the power to dictate land-use rights shifts away from private citizens and toward government, states not only lower acquisition costs but also gain more flexibility in time frames and budgeting requirements. However, as the time frame for building the road moves from, say, a year to a decade, uncertainty grows among buyers and sellers of properties in these designated road corridors. Owners of these properties have great difficulty in selling a property that (1) may or may not be bought by the state at some future time and (2) has constraints that make it more akin to a rental since the owner of the rights to property improvement is a third party. As a result, these homeowners have few incentives to maintain their property and they have great difficulty in adding value since any building permits must go through a lengthy approval process.

We aim to test two hypotheses: First, as a result of changed incentives, homes that lie within a designated road corridor will suffer lower property values relative to similar, unaffected homes outside the road corridor. Note that here we are testing the value of the physical state of the house, using county tax-assessment data from 2013. The county does not measure the market value; nor do we, since there have been few sales over the past ten years because of severely depressed demand. Thus, we are limited to measuring the portion of the losses reflected in the physical shape of the house as noted by an independent tax assessor. As a result, any statistically valid findings from our research reflect the minimum hidden cost of the unbuilt road corridor in terms of lost property value. The true losses would be much larger if, say, these houses were put up for auction since bidders would pay a small fraction of the assessed value, given the restrictions set by the state.

Our second hypothesis concerns the potential spillover effect on homes adjacent to the designated corridor. The potential for noise, pollution, and even a change in the Department of Transportation plans could affect the incentive to both maintain and invest in these homes relative to unaffected homes further away. We use tax-assessment data to test this hypothesis as well.

We chose North Carolina because it had the worst attenuation of property rights through this type of legislation in the entire country until the legislation was overturned in July 2016 by the North Carolina Supreme Court. In the state, highways could be planned with no completion dates and no mandatory budgetary set-asides. Property owners within designated corridors had by far the longest wait time, three years, to get a response to a building-permit request. In particular, we focus our study on the Winston-Salem northern I-74 beltway project, which has seen the longest delays of all the state’s highway projects.

By analyzing what is perhaps the country’s most extreme case, we provide a methodology and means of partially assessing hidden costs when future roads are planned, budgeted, and built. The
point is that map acts may seem to represent a type of free lunch to some state officials, but this paper indicates that no such free lunch exists, that the costs are real. We find that savings to the state in terms of cheaper acquisition of homes are more than offset by falling real estate values relative to those of nearby properties outside the designated corridors.

Using multivariate regression analysis, we examine the impact on the tax-assessment values for three groups of homes: those within a designated road corridor, those within a parallel band of properties within a quarter mile from the beltway, and those within a second parallel band of homes lying between a quarter and a half mile away. All estimates are relative to homes more than a half mile away. This presents an ideal natural experiment since this map act was applied in a way that was unanticipated by virtually all homeowners in the area when they originally purchased their home.

The paper proceeds as follows: Section 2 examines the pertinent scholarly literature on the subject and also offers a framework and model for understanding the impact of the Map Act both on homes within and alongside a designated road corridor. Section 3 provides background information and an overview of the case study. Specifically, it provides detailed information on North Carolina’s Map Act and details on the northern beltway. The hypotheses and research methodology, including an explanation of the GIS techniques utilized to complete our analyses, are discussed in section 4 of the paper. Section 5 includes the findings from the multivariate regression analysis. Finally, section 6 provides a discussion of policy implications for both state and local governments, a summary of the study’s main findings, and ideas for future research endeavors.

II. LITERATURE REVIEW

Previous scholarly work by transportation experts tends to emphasize net benefits to the state economy after highways have been completed (Palmquist and Boyle 1982; Guiliano 1988; Weisbrod and Beckwith 1992; Ryan 1999; Weiss 2002). Ryan (1999, 423) noted that though positive, property-value effects tend to “occur close to a facility, within one mile for highways.” Since these and other cost-benefit studies generally show positive effects of building roads, it follows that state governments have incentives to make plans to build the roads, as the costs of the plans are small relative to the benefits. Moreover, states have an incentive to maximize the perceived net benefits by freezing the costs of eventual property acquisition in order to plan even more roads. However, as we suggest in our first hypothesis, a frozen property market creates collateral damage to property owners, and these unmeasured regulatory costs do not appear in traditional economic cost-benefit analyses of building roads.

Moreover, in keeping with our second hypothesis, homeowners (and future buyers) with rational expectations living adjacent to a planned road corridor may take into account the future consequences of potential noise and traffic, and other consequences of an eventually built road. For example, the return on investment will be lower on a home next to a highway than a home next to a beautiful meadow. Lake et al. (1998) found a negative link between environmental conditions (i.e., noise and visual intrusion) and property prices. Wilhelmsson (2000) also specifically demonstrated that road noise negatively impacted property prices.

III. MAP ACTS AND ROAD CORRIDORS

As previously discussed, road corridors are designated spaces where the state plans to build a future road when it comes up with the money or initiative. Using a state roadway-corridor map, referred to by the state of North Carolina as an “official map,” the state essentially places a hold on homeowners’ property rights in order to keep an option open to build a road at some future time. The corridor map is defined as “a map, drawing or written description of a planned roadway
alignment, with approximations of future right of way boundaries, which is adopted by the Board of Transportation for right of way protection purposes.”

The implementation in North Carolina of this type of map began in 1987, when the North Carolina General Assembly passed the North Carolina Map Act with the rationale that it would allow for the North Carolina Department of Transportation (NCDOT) to protect rights of way for “important highway projects.” Of the other twelve states with map acts, eleven have statutes that limit permit delays for a decision about acquisition to 365 days or less (Younts 2014). The limit in Tennessee is the shortest, at eighty days.

Prior to July 2016 (when the North Carolina Map Act was overturned), there were twenty-four North Carolina Map Act projects spanning eighteen counties. If homeowners wished to move, they would apply for permission to the state, which evaluated cases based on perceived hardship to the owner. In the case of medical or economic reasons, the state could agree to acquire the property even if the road had not yet been built. The NCDOT notes that “the adoption of such a map places temporary restrictions on private property rights by prohibiting for up to three years the issuance of a building permit or the approval of a subdivision on property within an adopted alignment.” The land was protected from “certain activities,” which means people were not allowed to use their property in ways they once did. Homeowners could not build new structures, such as garages, or obtain building permits for any reason unless approved by the state, which had up to three years to make a decision. According to the NCDOT website, people were allowed to make repairs and undertake light renovations that did not require building permits, such as painting or putting in a new sink. Each time a new permit was requested, the homeowner faced another wait of up to three years, leading to only a handful of sales in the planned area since 1987.

Note that the state allowed the property owners to petition for a variance, but “the burden of proof lies with the property owner.” This procedure transferred the cost of protecting property rights away from the state and added substantial uncertainty to the present and future use of the property. In general, the NCDOT had three years to respond to any petition for a variance. If the state so decided, the homeowner who was interested in a building permit might be, in some cases, allowed to make “limited improvements” that might otherwise have been prohibited. Homeowners faced a set of options for appeals, which could take years to decide. Younts (2014) noted that “concerns over the indefinite nature of the Map Act were raised by multiple justices during oral argument in late 2013 at the North Carolina Supreme Court.”

The NCDOT had up to ten years to evaluate whether the corridor protection was still necessary. Since the corridor protection could be renewed at no cost to the state (barring lawsuits), homeowners could sit in limbo for more than a decade. This is the case with the planned northern beltway in Winston-Salem, NC, which has been called the poster child for delays arising from the North Carolina Map Act (Younts 2014).

A. THE WINSTON-SALEM NORTHERN BELTWAY: A SHORT HISTORY

In 1987, the NCDOT adopted the Winston-Salem Forsyth County Thoroughfare Plan, called “the northern beltway,” to enhance connectivity to the region, state, and country. The roads that then served the area, in particular US 421 and US 52, bore far more traffic than they were originally designed for, leading to ongoing traffic jams. The beltway project was to begin at US 158 southwest of Winston-Salem and end at US 311 southeast of the city, with a total length of 34.2 miles (see figure 1).
For homeowners lying in the path of the future beltway, their incentives to invest in their property diminished after learning of the 1987 plan to eventually demolish their homes. By 1997, the NCDOT had designated the majority of the western side of the beltway as a “designated highway corridor” under the Map Act, effectively freezing any development for hundreds of property owners (see figure 1). The eastern side, still part of the 1987 thoroughfare plan, was officially designated a highway corridor in 2008 under the Map Act, as seen in figure 1 as well.

Construction was set to begin in 1999, but environmental lawsuits put the project on hold until 2004. By 2004, state budget shortfalls had further pushed back the project to 2012, and new environmental lawsuits in 2008 led to further delays as well as an estimated doubling of the cost of the project. By 2012, the DOT had acquired about 460 properties under the Map Act, but in 2014 homeowners found that the NCDOT ranked the northern-beltway project 1,389th out of 1,700 road projects according to its needs-based scoring (WS Chamber 2013). However, in late 2015 Governor McCrory announced that the eastern side of the northern-beltway project was one of twenty-one “priority” projects that would be funded through a bond referendum. This would only fund the eastern side of the beltway, however, which has the most commercial traffic. (Young 2015). Property owners on the western side of the beltway would remain in limbo for another year until the 2016 legislative

Figure 1. Proposed Northern Beltway in Forsyth County, NC.

action by the governor that was previously mentioned, but both the 2015 and 2016 events are outside the time frame of this analysis since we use 2014 data.

B. THE TAKINGS DEBATE

The designated beltway corridor near Winston-Salem became the center of a years-long lawsuit brought by affected homeowners against the state of North Carolina that was eventually settled in their favor by the North Carolina Supreme Court in July 2016. Shortly afterward, Governor McCrory revoked the Map Act for all currently planned highway projects (Young 2016). The central debate in the courts was over whether property owners suffered losses, or “takings.” Those losses, however, were never directly measured by the courts (as we do in this analysis), which no doubt extended the court battles.

The takings clause of the Fifth Amendment of the US Constitution states, “Nor shall private property be taken for public use, without just compensation.” This principle has been a mainstay of English common law since the Magna Carta and was incorporated into the US Constitution by the founding fathers. Eminent domain was put into place to protect private citizens and their property from government seizure without compensation (Paul 1988; Jones 2000; Schubert 2013). Generally, legal scholars agree that this clause refers to “direct expropriations or government-compelled permanent occupations of property” (PAS 2008).

Takings can take a number of forms and have been the subject of many court battles in the United States. In the simplest form, a direct condemnation results in the government taking private property for a public purpose and offering just compensation, often determined by the courts. A friendly taking, a more amicable process, can occur when a property owner agrees to sell the property to a government entity based upon an agreed price (PAS 2008). The courts have also ruled that takings can be temporary or permanent.

What constitutes a public purpose was the subject of a recent Supreme Court case (Kelo v. New London) that explored a local government’s use of eminent domain to seize fifteen homes to promote the “public purpose” of a private economic development project. In the end, the Supreme Court ruled in favor of the local government and approved economic development as a viable public purpose (Lopez and Totah 2007). This decision resulted in many state laws that limited local governments’ ability to utilize eminent domain for economic development efforts.

Finally, a larger body of legal decisions has focused on inverse condemnations. Under this area of law, takings that are physical, regulatory, or both may occur when the government places burdens on private property, usually through legislative actions. Numerous court cases have explored this form of takings, including Loretto Teleprompter Manhattan CATV Corp. (1982; a physical taking), Lucas v. South Carolina Coastal Council (1992; a regulatory taking), and Dolan v. City of Tigard (1994; a regulatory taking) (PAS 2008). According to Schubert (2013), “While every regulation of property diminishes the owner’s freedom in some respect, not every regulation can be deemed a taking.”

The North Carolina Supreme Court ruled that the North Carolina Map Act stretched far beyond the bounds of any of the above cases because of the combination of the infinite time horizon of the roadway designation and the lack of compensation for the losses. Epstein uses the idea that property rights are a bundle of sticks and argues that the state must pay for “each stick in the bundle that it takes” and is never allowed to say “it can take one or more sticks for free as long as the original owner keeps some residual sticks” (Epstein 2011, 233). There should be no sticks in the property rights
bundle that move between the private and public domain at “legislative whim” (Epstein 1985, 85). The North Carolina Map Act seems to have fallen into this category of taking some “sticks” without compensation. This had the effect of making it difficult, if not impossible, for owners to upgrade or sell their properties, which are some of the prime reasons for owning a home in the first place.

What is also unusual is that this type of taking resulted in no direct benefit to anyone, except to give the state unlimited time and flexibility to decide on when (if ever) a road would be built. This resulted in tremendous uncertainty in the affected housing market. In the next part of the paper, we advance a method to measure how large this deadweight loss was for the affected property owners of Winston-Salem.

IV. MODELING UNCERTAINTY IN REAL ESTATE MARKETS

Despite the overturning of the Map Act in 2017, affected homeowners still faced uncertainty. There is still legal wrangling over what proper compensation from the state of North Carolina should be, and no clear way to measure the complete damage over the years to homeowners who lost their ability to upgrade or sell their properties. To evaluate and measure the approximate deadweight loss to property owners in terms of real estate value, our analysis draws upon the theories of the German economist von Thünen (1826), who may be little known to many readers. His theories of land rents provide a compelling yet simple way to model how externalities affect land prices.1

Von Thünen was the first to model the relationship between city centers and land prices. He suggested the reader first imagine a flat, featureless plain with no rivers, forests, or mountains and thus stable and equal rents across the land. Then he asked the reader to imagine a thriving city center. The reduction in transportation costs for merchants engaging in trade and sales would raise rents in the very center, and those rents would diminish in value as the distance from the city center increased.

Using von Thunen’s assumptions when modeling the impact of the beltway, we can imagine the theory operating in reverse. As we have seen, an unbuilt beltway curtails the owners’ right to upgrade their property and creates disincentives to maintain the property. In addition, adjacent land is also affected, as a function of its distance from the corridor, for reasons discussed earlier. Instead of an inverse-V-shaped increase in wealth around city centers, road corridors create V-shaped depressions in land values. Homeowners most affected are those who lie directly in the beltway’s path. Even if only a corner of their property touches the corridor, it creates uncertainty for any future buyer. Figure 2 shows this with the depression of property values, A−B, which represents a cross-sectional slice. We posit the damaging effect of the beltway will lessen at a constant rate as one moves away from the beltway. This is shown by the sloping values between A and B in figure 1. In our study, we posit that property owners up to a quarter mile away could be affected by the spillover effects of some future road, including the uncertainty of moving the road’s physical location or the expected potential increase in road noise. After a quarter mile, we hypothesize that property values return eventually to their previous level, shown by

the values in the quarter-to-half-mile buffer (and implicitly, beyond) in figure 2.

V. HYPOTHESES AND RESEARCH METHODS

The underlying goal of this research study is to evaluate the impact of North Carolina’s Map Act on residential housing values within a planned beltway north of Winston-Salem, NC. The study examines a specific planned transportation facility (the proposed northern beltway) in Forsyth County, NC, that was developed through the use of North Carolina’s Map Act (see figure 1). This particular case makes for an excellent case study because it allows one to analyze long-term changes in economic outcomes as a result of changes in property rights relative to outcomes for neighboring properties up to one half mile away that experienced no such changes.

We hypothesize that this market uncertainty and corresponding loss of property rights in a designated road corridor will directly cause two observable effects: First, the existing value of the beltway property will decline over time relative to that of neighboring properties free of the restrictions of the Map Act, as owners lose the incentive (or indeed, ability) to upgrade or maintain their properties. We also posit a second, related hypothesis: spillover effects are negative and higher for residents who live directly adjacent to the road corridors relative to those who live further away. We expect these residents will suffer a loss of property value as well, although less than that for residents directly in the beltway’s path. Uncertainty arises for these residents since there is greater risk that the government’s plans for the road may change and impact nearby residents not currently impacted by a map act. For example, a planned freeway exit could move to a new location over a given period of planning. In addition, lower values today may come about from an expectation about a highway’s future road noise, pollution, and congestion.

Note that depressed property values are important from the perspective of the local county since the depression means less property tax to be collected.

Figure 2. Model of Land Rents Based on a Planned but Unbuilt Freeway
even if the road is never built. This loss is not considered a cost from the viewpoint of the state since it does not collect property taxes on the affected properties. This potentially puts the aims of the state and the county at cross-purposes. It must also be noted that the county may decide to support a planned or proposed transportation facility with the knowledge of lost tax revenue in the short term with the expectation of greater revenues in the future as a result of potential development spurred on near the transportation facility.

Our regression model is the following:

\[ \text{RESVALUE} = a + \beta_1 \text{(BELTWAY)} + \beta_2 \text{(QURTMILE)} + \sum \beta (X) + \epsilon. \]

The primary focus is to assess the impact on residential housing values (RESVALUE) as a result of living directly in the planned beltway’s path (BELTWAY) or within a quarter mile (QURTMILE). This model also allows us to estimate the impact of an array of other independent variables (X) including state-government ownership, size of dwelling, housing quality, and distance to nearby amenities such as schools and parks. The constant is a, and \( \epsilon \) is an independent and identically distributed error term.

Using the dataset of 16,817 homes in Forsyth County, we employ ordinary least squares (OLS) regression analysis using Microsoft Excel. Data for RESVALUE came from the 2013 tax-assessment value for the residence, which was separated from the value of the land itself. Table 1 lists all the independent variables, their descriptions, and their hypothesized impact on RESVALUE. Including the value of the land, especially in homes with a lot of acreage, would somewhat muddy the results because open land experiences fewer (if any) upgrades as well as little, if any, depreciation. Thus, the use of residential value as a dependent variable is intended to more directly measure the consequences of the Map Act’s impact on housing values within the proposed beltway.

For those within-beltway homes, as we have seen, it was very difficult to obtain building permits for upgrades and additions. This deterred or even prevented homeowners from making typical improvements such as upgrading kitchens, basements, or attics, or adding a garage or outbuilding. In addition, the Map Act created disincentives for home maintenance, which should also have lowered the appraised value over time, as homeowners delayed incurring the cost of activities such as painting or re-siding the exterior, repairing roofs, and repaving driveways since those costs would not be recovered through either a sale or an NCDOT acquisition.

Ideally, one would like to know the market value of homes inside the beltway versus outside of it. Unfortunately, this is impossible since the market for homes within the beltway has more or less shut down because of a lack of interested buyers over the past decade. Thus the dependent variable RESVALUE, using tax-assessment values, captures the best guess at the market value if there were a functioning real estate market within the beltway.

Using the same measure for houses outside the beltway gives a better comparison of changes in property values for both areas over the twenty-five-year period since the Winston-Salem beltway plan was announced by the NCDOT. In other words, RESVALUE measures the overall difference in incentives to both maintain and upgrade property within designated corridors as compared to property outside the corridor. For this reason, we do not control for independent variables that might be subject to deferred maintenance, such as the age of roofs. Doing so would potentially undercut the RESVALUE’s estimate of the total drop in property values due to the different incentives caused by a property lying within the corridor.
According to the Forsyth County tax assessor’s office, assessments do not downgrade home prices for being in designated highway corridors, even if there are great difficulties in making sales. Homes are simply assessed using comparable listings in nearby areas, making it possible to make objective comparisons based solely on the physical attributes of the property.

The variable BELTWAY captures the impact on residential housing values within the planned beltway. Based on our earlier hypothesis, the predicted sign for BELTWAY is negative. The spillover effects on properties adjacent to the planned corridor (within a quarter mile) are captured by the QUURT MILE dummy variable, which is expected to be negative but smaller than the BELTWAY variable. Both variables’ estimated coefficients should be interpreted as relative to the reference group of homes that lies in a band between a quarter and a half mile away.

Because we are looking at overall values of homes along a thirty-four-mile span, we are primarily interested in the potentially large-scale effect of proximity to the planned beltway. There may be other, small-scale effects, in that a poorly maintained home may negatively impact a nearby home’s property values for reasons unrelated to the beltway. However, the area of the county that the beltway traverses is largely rural, so negative neighborhood effects

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
<th>HYPOTHESESIZED VALUE (+ OR -)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELTWAY</td>
<td>Indicates whether a residence lies at least partially inside the designated corridor</td>
<td>Dummy</td>
<td>Tests for depreciation of property values as a result of being in pathway of designated unbuilt corridor</td>
<td>(-)</td>
</tr>
<tr>
<td>QUURT MILE</td>
<td>Indicates whether the residence was in a quarter-mile buffer adjacent to the designated corridor</td>
<td>Dummy</td>
<td>Tests for spillover effect of unbuilt designated highway on adjacent homes</td>
<td>(-)</td>
</tr>
<tr>
<td>DOTHOME</td>
<td>Indicates the home is owned by the NCDOT</td>
<td>Dummy</td>
<td>Tests for difference of assessed property value from state acquisitions of property</td>
<td>(-)</td>
</tr>
<tr>
<td>BRICK</td>
<td>Indicates whether the residence has a brick exterior</td>
<td>Dummy</td>
<td>A measure of quality of the home</td>
<td>(+)</td>
</tr>
<tr>
<td>AGE</td>
<td>Age of the home in years, as of 2015</td>
<td>Continuous</td>
<td>A measure of depreciation of the home, yearly</td>
<td>(-)</td>
</tr>
<tr>
<td>SQUAREFT</td>
<td>Square footage of the residence</td>
<td>Continuous</td>
<td>A measure of value of the home, using space</td>
<td>(+)</td>
</tr>
<tr>
<td>SCHOOL DIST</td>
<td>Distance to the nearest school, in thousands of feet</td>
<td>Continuous</td>
<td>A measure of market value of nearby amenity: school</td>
<td>(-)</td>
</tr>
<tr>
<td>GROC DIST</td>
<td>Distance to the nearest grocery store, in thousands of feet</td>
<td>Continuous</td>
<td>A measure of market value of nearby amenity: grocery store</td>
<td>(-)</td>
</tr>
<tr>
<td>PARK DIST</td>
<td>Distance to the nearest public park, in thousands of feet</td>
<td>Continuous</td>
<td>A measure of market value of nearby amenity: public park</td>
<td>(-)</td>
</tr>
</tbody>
</table>
should be slight and uncorrelated with each other. In addition, the quarter-mile-buffer dummy variable is used as a way to present a better overall picture than using a continuous variable, such as tenths of a mile from the beltway. In the latter case, precision would be gained but scope in the larger context would be lost. We also test for any systematic differences in property values between privately owned properties and those owned by the NCDOT. Our hypothesis is that property that is not privately owned will not be maintained as well; hence the expected sign on the DOTHOME dummy variable is negative.

One possibility that arises is that perhaps the homes within the beltway were cheaper to begin with, since the state would want to minimize acquisition costs in building a beltway. We acknowledge that this is a shortcoming of our study since data are not available pre-1987 and so we cannot make a before-and-after comparison. However, since all of the comparison properties are within a half mile of the planned highway corridor, we think it is a reasonable assumption that the properties have roughly similar distributions of assessed prices and characteristics. Thus, a cross-sectional analysis is the next best way to measure statistically significant differences caused by the imposition of the planned corridor, if time series is not available.

Note that from the day in 1987 that property owners received word of an impending highway and potential razing of their homes, there was far less rationale to invest in home improvements such as a new roof, a garage, or an upgraded kitchen. It would not be until ten years later that, in 1997, homes on the western side of the beltway were officially restricted from making such investments under the North Carolina Map Act (and not until 2008 for homes on the eastern side of the planned beltway). Throughout the decades, very few homes were bought and sold on either part of the beltway. There is a strong argument to be made that rational and forward-thinking decision-makers would have made very different investments in property improvements even before the restrictions were made official.

A. DATA METHODS: THE DESIGNATED CORRIDOR

Data on 2,270 properties falling within the I-74 beltway were obtained from the North Carolina Department of Transportation (NCDOT). On our request, the Forsyth County Tax Mapping Division mapped the I-74 beltway data collected by the NCDOT using the software ArcGIS 10.3, creating a snapshot of the tax parcels as of January 1, 2013.

B. CREATING BUFFER ZONES USING GIS ANALYSIS

The next step was to create two comparison zones on both sides of the planned beltway, using the software program ArcGIS. First, ArcGIS 10.3 was utilized to create two parallel bands of property that followed the corridor on each side—hereafter called “buffers”—for a distance of up to one quarter mile away and between one quarter mile and one half mile away. This was done to aid in our understanding of the impact of the proposed transportation facility on residential property values at different distances from the proposed highway. Figure 3 shows this map of the planned beltway with the added buffers.

C. CREATING CENTROIDS TO IDENTIFY PROPERTY LOCATION

Properties do not always clearly lie either in the beltway or in one of the buffers; occasionally there is overlap between one section to the other. As a result, ArcGIS was used to place properties within a designated zone (i.e., beltway, quarter-mile buffer, or quarter- to half-mile buffer). This was accomplished through creating centroids for all of the tax parcels included in the 2013 Forsyth County tax-parcel dataset. A centroid is identified through an algorithm in GIS that finds the center of a parcel of land of any shape. This method quickly
determines which parcels lie within which area versus the alternative of making a judgment call on what is considered inside or outside of a particular buffer (see figure 4). Note that properties with a centroid that fell in the quarter- or half-mile buffer but still had a portion in the beltway were automatically assigned beltway status, as seen in figure 4. This is because the property is considered a beltway property by the state of North Carolina.

The creation of centroids allowed the placing of parcels in a particular area. Variables that referenced these locations were created for each property so regression analysis could be performed. The resulting data were then exported into an Excel spreadsheet. Note in some cases the GIS analysis placed a designated beltway property in the quarter-mile buffer. This was because the property overlapped the two regions and the centroid calculated as outside the designated highway corridor. However, from the perspective of the local marketplace, even a property that has just a small section lying in the corridor is considered tainted by the local real estate market and highly avoided by buyers. Therefore, all 2,270 properties in the designated corridor were designated as beltway properties regardless of whether the GIS centroid analysis put it in one of the two buffer zones. The GIS analysis put such properties in a buffer zone in fewer than 1 percent of the cases.

D. DELETION OF NONRESIDENCE PROPERTIES

Once exported to Excel, the dataset from the county tax records now contained 23,372 properties. This included all properties in the planned beltway (2,270 properties) plus properties from the two parallel buffers, lying up to a quarter mile away and between a quarter and a half mile away.

For the purpose of our analysis, we only included properties that had physical residences on them, as
these would be more likely than open land to suffer depreciation from market uncertainty. Deleting cases with no homes on the property yielded a complete dataset of 16,817 observations comprised of 1,164 beltway properties and an additional 15,653 buffer properties. Within the buffer area, properties were placed in either the quarter-mile buffer (7,323 properties, or 43.6 percent of the total) or the quarter- to half-mile buffer (8,328 properties, or 49.5 percent of the total). These buffers served to be useful controls to measure the values of neighboring properties against the values of those properties lying directly in the beltway’s path. Additional property-specific information from county tax records was also included to create measures of house quality and location.

VI. RESULTS
A. IMPACT OF DESIGNATED HIGHWAY CORRIDOR ON HOUSING VALUES IN FORSYTH COUNTY

Table 2 first shows the difference in average RESVALUE by location: within the beltway, within the quarter-mile buffer, and within the quarter- to half-mile buffer. We can see significant differences in assessed values between those homes lying directly in the planned beltway’s path ($91,268) versus those up to a quarter mile away ($103,162) versus those between a quarter and a half mile away ($113,631). It seems highly unlikely that a planned beltway could consistently connect properties that were significantly cheaper than other properties literally in sight of them in many instances. This is good initial evidence of

Note: Properties with a centroid that fell in the ¼ or ½ mile buffer but still had a portion in the beltway were automatically assigned beltway status, as seen in the figure. This is because the property is considered a beltway property by the state of North Carolina.
systematic differences in property values caused by the highway corridor.

To investigate further, we performed an ANOVA test to test for the null hypothesis that the means of the assessed residence values across all three zones (beltway, quarter-mile buffer, quarter-to-half-mile buffer) were not statistically significantly different from each other. The null test was strongly rejected at the 99 percent level of confidence, with the calculated F-value of 103.7 far exceeding the critical F-value of 3.84. Two post hoc t-tests were then performed that assumed equal variances but unequal sample sizes. The first two-tailed t-test had as its null hypothesis that there was no difference in means of assessed residence values between the half-mile buffer and the quarter-mile buffer. This too was strongly rejected, with a t-statistic of 10.18 versus a critical t-value of +/−1.96. Following that, a two-tailed t-test was performed that had as its null hypothesis that there was no difference in means between the beltway properties and the properties in the quarter-mile buffer. This also was strongly rejected with a t-statistic of 7.02 versus the critical t-value of +/−1.96. Lastly, a z-test was used to test whether the sample of assessed residence values of the 1,164 beltway homes differed significantly from all 111,001 homes in Forsyth County. Using a two-tailed z-test, the calculated z-value was −54.34, with a critical z-value of +/−1.96. This also strongly rejected, at the 99 percent level of confidence, the null hypothesis that the beltway sample was random and representative of the county population.

Having established that these groups were

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>NUMBER OF CASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>In beltway</td>
<td>$91,198</td>
<td>$47,822.81</td>
<td>1,164</td>
</tr>
<tr>
<td>Up to 1/4 mile away</td>
<td>$103,162</td>
<td>$54,914.64</td>
<td>7,325</td>
</tr>
<tr>
<td>Between 1/4 and 1/2 mile away</td>
<td>$113,631</td>
<td>$71,376.86</td>
<td>8,328</td>
</tr>
<tr>
<td>Entire county</td>
<td>$106,621</td>
<td>$94,917.00</td>
<td>111,001</td>
</tr>
</tbody>
</table>

Table 2. Forsyth County, NC: average value of residential property (less land)

Note: An ANOVA test was performed on the three zones (beltway, 1/4 mile buffer and 1/4- to 1/2-mile buffer. The null hypothesis that all means were equal was strongly rejected at the 99% degree of confidence. Post hoc t-tests indicated zones were statistically different from each other. Lastly, a z-test indicated the beltway sample was statistically different from the entire county population, at 99% confidence. See text for more details.
statistically significantly different with regard to assessed residence value, regression analysis then provides a more sophisticated way to control for differences in household quality. Thus, these results should be seen as a better determination of differences between the beltway and the buffer areas than simple averages. Table 3 shows the means and standard deviations of all variables used in the regression.

Table 4 presents the regression results. As seen in Table 4, the independent variable BELTWAY measures the direct impact of homes lying within the proposed highway beltway. The coefficient estimate was $-11,798$, indicating the difference in assessed value between these homes and those in the reference group. (The reference group was those homes that lay in a band alongside the beltway between a quarter and a half mile away.) The result was overwhelmingly statistically significant, at greater than 99 percent confidence. An interpretation of this value is that this is direct evidence that the planned but unbuilt northern beltway has resulted in these homes getting fewer upgrades and maintenance than homes outside of the beltway, holding other factors constant.

The implicit cost of living near the unbuilt beltway was measured for homes directly adjacent to the beltway’s planned path and up to a quarter mile away using the variable QURTMILE. In this band of property, the estimated coefficient was $-5,931$ relative to the outermost band of property, which could be seen as an implicit price or penalty. Since the North Carolina DOT has shifted beltway plans over the years, this could reflect the implicit price of the uncertainty of living close to the beltway as well as the expected externality of road noise and pollution as a result of the close proximity, which results in less homeowner investment. This finding was also overwhelmingly statistically significant with greater than 99 percent confidence.

Table 3. Means and standard deviations of variables

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE</th>
<th>MEAN</th>
<th>ST. DEV.</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential value ($)</td>
<td>107,518</td>
<td>63,563</td>
<td>n/a</td>
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</table>

<table>
<thead>
<tr>
<th>INDEPENDENT DUMMY VARIABLES</th>
<th>MEAN</th>
<th>ST. DEV.</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beltway property</td>
<td>0.069</td>
<td>0.254</td>
<td>1,160</td>
</tr>
<tr>
<td>1/4 to 1/2 mile band</td>
<td>0.436</td>
<td>0.496</td>
<td>7,332</td>
</tr>
<tr>
<td>1/2 mile buffer (ref. group)</td>
<td>0.495</td>
<td>0.500</td>
<td>8,324</td>
</tr>
<tr>
<td>NCDOT-owned</td>
<td>0.010</td>
<td>0.101</td>
<td>168</td>
</tr>
<tr>
<td>Brick exterior</td>
<td>0.380</td>
<td>0.485</td>
<td>6,390</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTINUOUS VARIABLES</th>
<th>MEAN</th>
<th>ST. DEV.</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of house</td>
<td>32.9</td>
<td>37.4</td>
<td>n/a</td>
</tr>
<tr>
<td>Square footage of house</td>
<td>1,695.1</td>
<td>930.2</td>
<td>n/a</td>
</tr>
<tr>
<td>Dist. to nearest school (1000s of ft)</td>
<td>6.1</td>
<td>2.79</td>
<td>n/a</td>
</tr>
<tr>
<td>Dist. to nearest grocery (1000s of ft)</td>
<td>7.22</td>
<td>3.13</td>
<td>n/a</td>
</tr>
<tr>
<td>Dist. to nearest park (1000s of ft)</td>
<td>7.68</td>
<td>2.89</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Total observations: 16,817
The independent dummy variable DOTHOME indicated whether the NCDOT owned the residence within the beltway. (No homes in the dataset outside the beltway were owned by the NCDOT.) The coefficient estimate for DOTHOME was 8,371, indicating these homes’ higher appraised value versus non-DOT-owned homes in the proposed beltway. A measure of the full impact of having a NCDOT-owned beltway home (relative to the reference group) is the sum of the coefficients of BELTWAY and DOTHOME. This is −3,471, meaning $3,471 less than the reference group of homes in the quarter- to half-mile band alongside the beltway.

The higher value of NCDOT-owned beltway homes relative to other beltway homes merits more consideration. It is consistent with the hypothesis that the NCDOT has been more interested in acquiring new sources of revenue rather than in minimizing the long-term costs to the local residents of building a new road. A reason for the state to acquire higher-valued homes first is that they can earn more rental income. Note the importance of this finding: if the state government were interested in minimizing costs to taxpayers and Forsyth County of building the road, they would acquire the least expensive homes first and the most expensive homes last, particularly since many homes are being razed and properties left empty. This way, the loss of property taxes to Forsyth County would be minimized since the state does not pay property taxes once it acquires homes. This finding indicates that the goals of the state and the county may be in conflict, or at least not congruent. The t-statistic for DOTHOME was 2.00, which indicates 95 percent confidence in this finding.

Homes with a brick exterior were measured with the dummy variable BRICK. The regression estimated an increase of $27,524 in assessed value versus homes with wood, stucco, or vinyl exteriors, at a 99 percent level of confidence. BRICK could also be capturing other, unmeasured quality variables correlated with brick exteriors, such as paved driveways, upgraded kitchens, and so forth. The age of the house (AGE) is a measure

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>COEFFICIENT</th>
<th>T-STATISTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT</td>
<td>Intercept</td>
<td>57,611.90</td>
<td>30.54</td>
</tr>
<tr>
<td>BELTWAY</td>
<td>Betway property</td>
<td>11,789.36</td>
<td>-6.80</td>
</tr>
<tr>
<td>QURTMILE</td>
<td>1/4 to 1/2 mile band</td>
<td>-5,931.10</td>
<td>-7.17</td>
</tr>
<tr>
<td>DOTHOME</td>
<td>NCDOT-owned home</td>
<td>8,371.01</td>
<td>2.00</td>
</tr>
<tr>
<td>BRICK</td>
<td>Brick exterior</td>
<td>27,524.67</td>
<td>33.28</td>
</tr>
<tr>
<td>AGE</td>
<td>Age of house as of 2015</td>
<td>-315.11</td>
<td>-29.64</td>
</tr>
<tr>
<td>SQUAREFT</td>
<td>Square footage of home</td>
<td>32.34</td>
<td>75.05</td>
</tr>
<tr>
<td>SCHOOLDIST</td>
<td>Dist. to nearest school</td>
<td>-434.85</td>
<td>-3.05</td>
</tr>
<tr>
<td>GROCDIST</td>
<td>Dist. to nearest grocery</td>
<td>-417.70</td>
<td>-3.21</td>
</tr>
<tr>
<td>PARKDIST</td>
<td>Dist. to nearest park</td>
<td>517.81</td>
<td>3.71</td>
</tr>
</tbody>
</table>

Adjusted R-squared = 0.356
Number of observations = 16,817
F-statistic = 1,034.7
Note: All coefficients were significant at the 99% degree of confidence except for NC-DOT, which was significant at the 95% degree of confidence.
of ongoing depreciation of a physical asset not subject to the owner’s control (as a roof or other maintenance item might be), and the coefficient and the negative sign are consistent with our hypothesis. They indicate that the assessed value of the house dropped by $315 per year since it was built. The variable measuring square footage of the house (SQURFT) had a positive sign, indicating that controlling for the other independent variables, each square foot of the house contributed an additional $32 to the assessed value. This had the highest t-statistic, at 75.05, clearly exceeding the 99 percent confidence level.

Three other continuous variables measured distance to nearby amenities that might be important to homeowners: schools, grocery stores, and parks. All the estimated coefficients were significant at the 99 percent confidence level. The estimated coefficient for SCHOOLDIST means that for every thousand feet between the nearest school and the residence, the property value dropped by $435, indicating proximity to schools plays a role in property values. The estimated coefficient for GROCDIST also showed a similar impact, with a fall in housing values of $418 for every thousand feet from a residence to the nearest grocery store. Finally, the estimated coefficient for PARKDIST went the other direction; it indicated that for every thousand feet from the nearest public park, property values went up by $518, on average. This was contrary to our initial prediction, as we thought of parks as amenities valued by homeowners. However, upon further reflection, rural public parks may be hosts to crimes and loitering or may simply have that image among homeowners. This is speculation on our part and verifying it would require further research.

Several methods were used to test for multicollinearity in the results. The variance inflation factor (VIF) was calculated from our results as \( (1-R^2) = (1-0.356) = 1.55 \). A good rule of thumb is that if the VIF is greater than 10, then multicollinearity is likely to be high (Kutner et al. 2004). Clearly, our results are well below that threshold. In addition, the estimated coefficients were stable when taking out some independent variables and leaving in others in multiple regression runs. The variables were also all statistically significant, another sign that multicollinearity problems are not occurring and that the independent variables each have a role to play in explaining RESVALUE.

B. USING THE REGRESSION RESULTS TO IMPUTE COUNTY-WIDE LOSSES IN PROPERTY VALUE

As we have seen in the regression results from the BELTWAY coefficient, homes in the beltway have a value that averages around $11,798 less than that for homes a half mile away or more. This is equivalent to the distance \( A \) in figure 2, which showed the depression in land values. To calculate the total amount of the lost property value, we simply multiply this average loss by the number of homes in the beltway. As seen in table 4, the net difference is nearly $14 million. In addition, there is the loss that was predicted in figure 2 as \( (A-B)/2 \), the average loss from being near the beltway—that is, in the quarter-mile buffer. The coefficient estimate from the quarter-mile buffer QURTMILE \( (-5,931) \) is a good approximation of \( (A-B)/2 \) since it measures the average change in property value versus the reference group, the quarter- to half-mile buffer. Our regression results confirm that damage to neighboring property values is less than damage to beltway property values since the former properties do not lie directly within the designated corridor and therefore are allowed to obtain building permits. However, the damage from uncertainty and ever-changing beltway plans may have resulted in lower property values in this (quarter-mile) buffer. Table 4 indicates that the net...
loss here is $43.4 million, for a total imputed loss to the county’s property value of $57.2 million. Annual lost property taxes for the Forsyth County because of the unfinished beltway total $417,967 because of the estimated depressed market value. This naturally has consequences for the budget of the county, which must make up for budget shortfalls by either raising taxes or cutting benefits. Moreover, there are spillover effects on local businesses that serve households. And with homes rapidly depreciating over time, owners may see little need to repair homes that are unsalable and may be bought by the DOT at some future date.

VII. DISCUSSION AND CONCLUSION

This study has explored the relationship between residential home values and proximity to a DOT-planned highway with an uncertain time frame for completion. Specifically, it has examined the North Carolina Map Act, which was designed to save taxpayers money by freezing property values within a proposed transportation corridor. Our study has found significant losses not measured by the DOT in a designated highway corridor north of Winston-Salem, NC. This includes $57 million of property-value erosion for homeowners living in or near the decades-old unbuilt road corridor. The local county also lost nearly $418,000 in annual property tax revenue in 2013, according to our study’s calculations.

The results of this study show large and statistically significant differences in average assessed values between those homes lying directly in the planned beltway’s path ($91,268) versus those up to a quarter mile away ($103,162) versus those between a quarter and a half mile away ($113,631), as seen in table 2. Additionally, a more sophisticated regression analysis determined that residential dwellings with similar characteristics within the beltway corridor were valued almost $12,000 less than those in the comparison buffer (a half mile away or more). Homes adjacent to the beltway corridor (located in the quarter- to half-mile buffer) were valued almost $6,000 less than those in the comparison buffer. The overall fit of the regression analysis, measured using an F-statistic, showed greater than 99.9 percent confidence in the overall explanatory power of the regression model. This is the first direct evidence that the proposed road corridor has resulted in these homes getting fewer upgrades and less maintenance than homes outside of the beltway, holding other factors constant, as shown by statistically significantly lower assessed values. Additionally, this study has sought to determine the overall impact of the planned transportation facility, proposed through the use of the North Carolina Map Act, on local government finances. This study estimates that Forsyth County lost close to $57 million in property value as a result of the planned beltway.

Several key policy considerations can be gleaned from this report. First, the impact of the North Carolina Map Act on the finances of the state government was negligible, since property taxes are not a source of revenue for the state. However, local governments are severely impacted by this process of protecting transportation corridors, as a result of the decrease in property tax revenues. In North Carolina, more than a quarter of local government income is collected from property taxes (Malm and Kant 2013). Another policy implication of this research concerns the spillover effects related to the maintenance and upkeep of properties affected by the planned transportation facility. If property owners either are forbidden to make improvements to their property or opt not to make improvements out of uncertainty, either scenario will potentially lead to more zoning- and code-related issues for local government officials. Local governments, usually municipal or county planning offices, are
also often impacted by a moving target whereby the roadway corridor moves over time and who is impacted by the Map Act designation can change. In general, map acts can cause great consternation and lead to mistrust between residents and the local government.

It would be wise to explore the pre- and post-construction impacts related to transportation projects. As previously discussed, a research limitation of this study is the lack of assessed property tax values for residential properties in the corridor prior to the North Carolina Map Act designation for the planned roadway facility. As a result, it is difficult to assess the total impact of the designation on residential property values. Similarly, since the project is still under construction, it is unclear what the financial impacts of the project will be on property within the corridor if the road is ever completed. After construction, the community could see a rapid rise in property values along the corridor as a result of the new facility and improved access to the community. This in turn may spur a variety of economic development projects including new homes, businesses, and industries. Until that actually happens, though, uncertainty from the unbuilt roads creates deadweight losses for thousands of homeowners for years.

REFERENCES


