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Estimating The Impact of a Tolled Highway on Nearby Home Prices:

A Differences-in-Differences Study of Home Values in Wake County, NC

Abstract

Despite a growing body of literature on the impacts of highway infrastructure on home values, to date no studies have evaluated tolled highways' effect on home values. This study explores the effect of a recent tolled highway on home values in Wake County, North Carolina.

Study Objectives and Purpose

The impact of transportation infrastructure on local real estate has been a concern of researchers for several decades. Highway expansion is often cited as a net positive for local communities, as it boosts regional connectivity and economic development (Federal Highway Administration, 2017). However, highways can also incur externalities on local residents: highways are noisy, create pollution, and may heighten local traffic (Lekovich et al 2016).

Not all highways are the same, however. Because of the need to pay for entry, tolled highways are not accessible to all members of the public. Therefore, the impact of a tolled highway on a community is likely to have a different impact on a community than a non-toll highway. To date, very few studies have examined the impact that a tolled highway may have on home values. This study makes an important contribution to the literature by providing a first-of-its-kind Differences in Differences study to estimate the effect of tolled highway construction on single family home values in Wake County, North Carolina.

Motivation and Study Context

Wake County, North Carolina, is one of the fastest growing counties in the country (Wake County, 2022). By 2036, the county estimates that an additional 125,000 to 175,000 new housing units will need to be added to absorb the county's rising population (Wake County, n.d., *Growth and Population Trends*). Public transit is limited in Wake County, especially outside of the Raleigh city center. Thus, highways are the primary transportation connector for county residents. Wake County is in the process of building NC-540, a tolled beltway through Raleigh's outer suburbs. The beltway has opened in stages. This study seeks to answer: for homes within two miles of NC-540, what is the estimated impact of the beltway on single family home values?

Figure 1 shows the location of the study's beltway. Section A highlighted in red is I-540, the non-tolled portion of the road, an interstate highway that was completed in 2007. The remaining sections of the road are all state-funded tolled highways. The next section to be completed was Section B in 2012 (highlighted in purple). Section B branches off of I-540 by Raleigh-Durham Airport and extends south. Section C (highlighted in green) is slated to open in 2023 or 2024 to bring NC-540 east. Finally, section D (highlight in blue) is expected to open in 2033 to bring NC-540 north to reconnect with I-540.

This study will focus on single-family homes with proximity to two sections of NC-540: Sections B and C. Using a Differences in Differences approach, this study will estimate the effect of the 2012 opening of NC-540 on local home values.

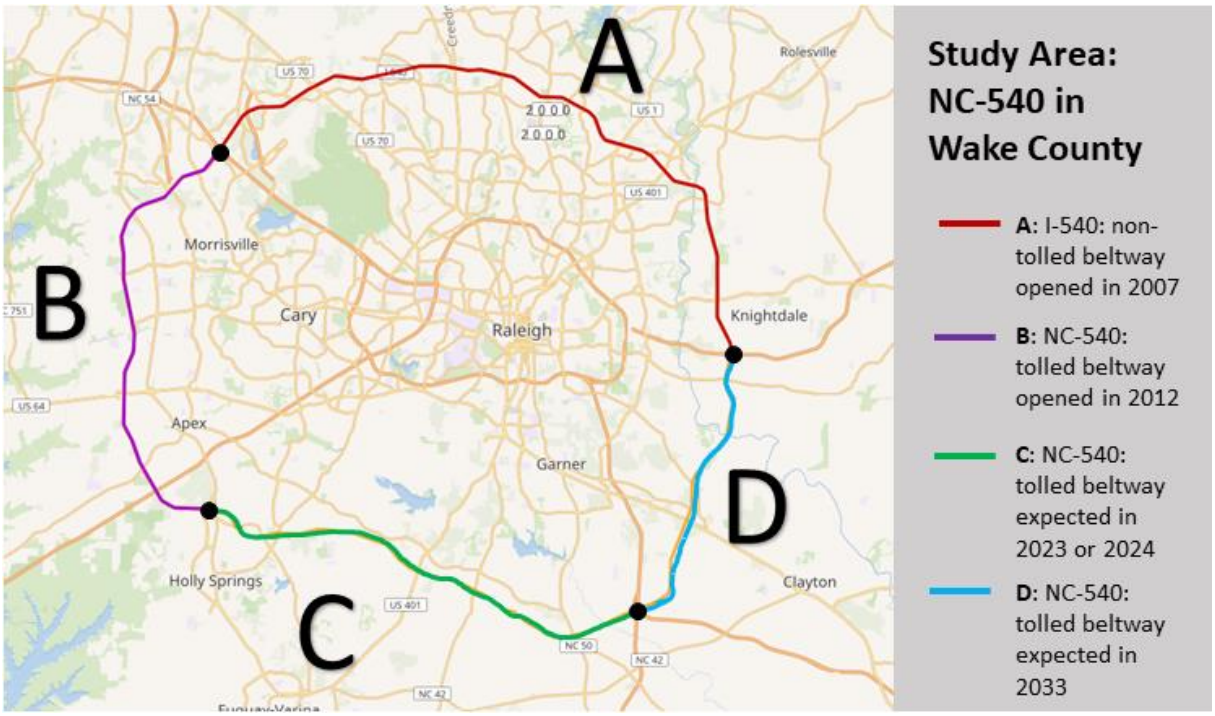

Figure 1: Study Area. Map modified from Wikimedia using data from OpenStreetMap contributors.

Conceptual Framework

Several studies have tried to understand the impact of highway infrastructure development on property values, with varying results. Maciel and Biderman (2013) found a positive effect on land prices in Sao Paulo, Brazil for parcels close to a new highway, as did Zhang et al (2022) in Hangzhou, China. Meanwhile, Lekovich et al. (2016) and Ossokina and Verwij (2015) found more modest impacts of highway development on housing prices in the Netherlands. In the US, Allen et al. (2015) found that homes near or adjacent to the highway in Orlando, Florida saw their values decrease.

The impact of highway infrastructure clearly varies across contexts. In North Carolina, Murray and Bardaka (2021) studied several North Carolina beltways, including I-540, the non-tolled extension of NC-540 (section A in the study context map). Using a Differences in Differences (DiD) approach, they found that homes located within 0.75-1.5 miles of an interchange saw the highest growth in home values, although this took 6-8 years to materialize. Whether Murray and Bardaka's 2021 finding of a positive impact will extend to the tolled extension of that same highway is an additional motivation of this study.

Studies of toll roads' impacts on home values are very limited. In my research, only one study considered the effect of a toll road. Boarnet and Chalermpong's 2001 study of home prices in Orange County, California found that home prices rose near a new toll road as home buyers were willing to pay a premium for greater accessibility to the road network. If also true in Wake County, this could mean that NC-540 will boost home values in the county. However, given the variation of the effects of highway infrastructure on home prices across the globe, it is important to investigate the specific impact of NC-540.

Methods

This study will use a Differences in Differences (DiD) approach to estimate the effect of NC-540 on nearby single-family home values after its 2012 opening. The treatment group is made up of homes within two miles of NC-540's existing entrances (Section B). The control group is made up of homes within two miles of NC-540's planned entrances along the incoming highway (Section C).

Data sources

This analysis uses Wake County's property tax assessments database of sales up to 2019, which records the most recent sale prices for all houses in Wake County (Wake County, n.d., Real Estate Property Data). This data is not longitudinal for each home, but rather only contains each house's most recent sale price and date. To focus on single-family homes and remove outliers, the dataset is filtered to only single-family homes with sales prices between $3,000 and $1 million. Homes last sold before the year 2000 and homes without valid sale years are also removed from the dataset to focus on the period of expected change. Finally, sales prices are adjusted for inflation and expressed in 2019 dollars according to the Consumer Price Index (U.S. Bureau of Labor Statistics, n.d.). This sales data is then georeferenced using Wake County's database of address points (Wake County, n.d., Address Points).

Finally, homes are selected for their inclusion in the treatment and control groups based on their proximity to highway entrances and exits. Homes in the treatment group are those sales located within a two-mile buffer of existing NC-540 highway entrances and exits. Homes in the control group are those sales located within a two-mile buffer of six estimated future NC-540 highway intersections. Homes within two miles of both existing and future highway intersections are excluded. Locations of existing highway entrances and exits are sourced from Wake County (Wake County, n.d., Street Intersections). Locations of future highway entrances are manually compiled based on satellite imagery of ongoing construction and cross-referenced with NC-540 construction maps (NC DOT, n.d.).

The final data set is made up of 43,894 Wake County home sales. The table below shows the number of observations in each group in the study.

Group	**Post-Highway Opening** (2012-2019)	**Pre-Highway Opening** (2000-2011)	**Total Observations**
Treatment (Access to NC-540)	20,472	11,070	**31,542**
Control (No access to NC-540)	7,053	5,299	**12,352**
Total Observations	**27,525**	**16,369**	**43,894**

The homes in the analysis are mapped below by treatment and control group status. Homes within the treatment group are in blue, while homes within the control group are in pink. NC-540 and its intersections (existing and future) are mapped as well.

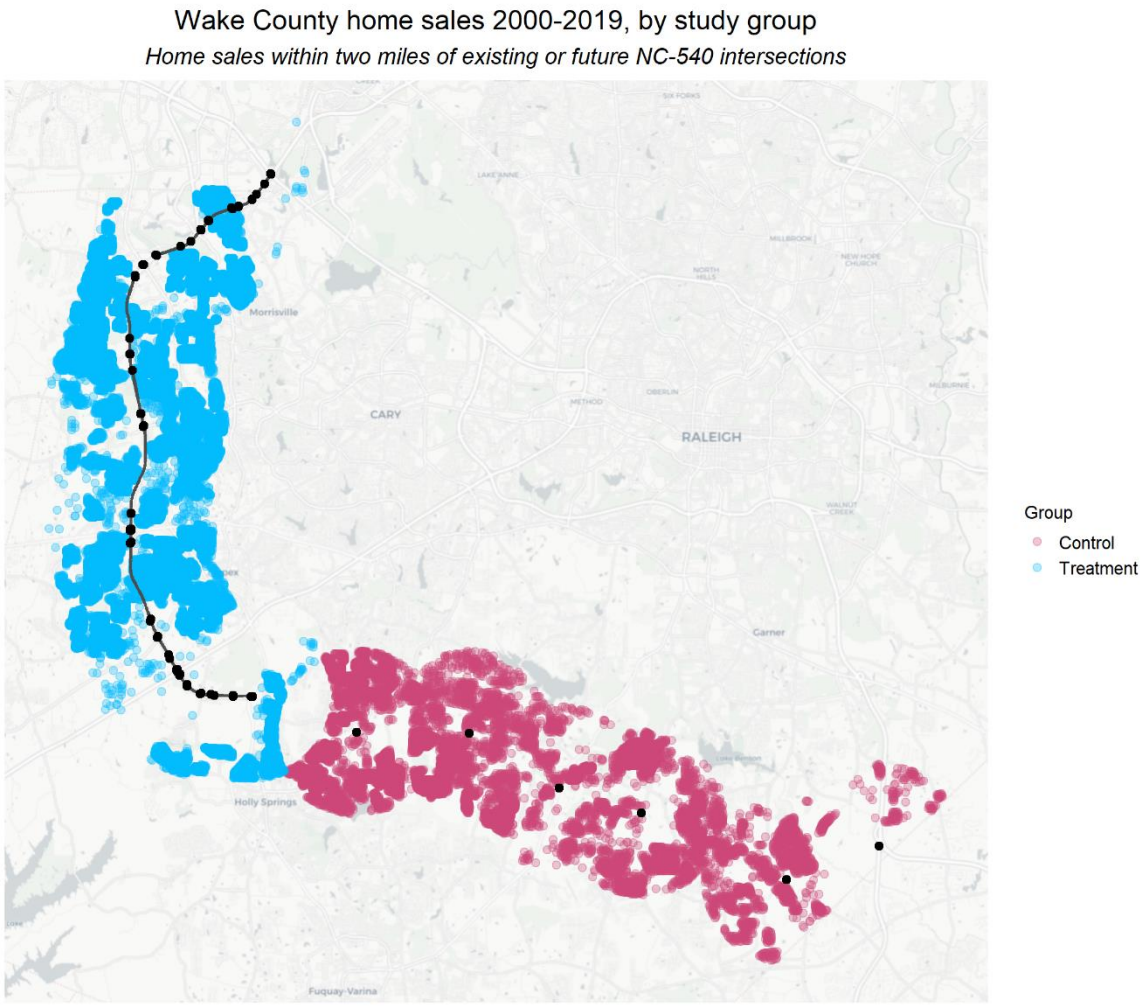

Figure 2: Study homes by treatment and control status.

Data Analysis

Following a traditional Differences-in-Differences (DiD) approach, this study calculates the average adjusted sale price for homes across time (within control/treatment groups) and across control/treatment groups (within time). The difference between each section is taken to find the overall value of the change attributed to the highway opening (delta). A DiD model is also run to confirm these results. The results of both of these analyses are discussed in the following section.

Next, a second DiD regression is run, while controlling for price indicators in order to more completely capture any home value differences. These price indicators include heated area, acreage, and the number of stories of each home. The results of this regression are discussed in the following section.

Finally, a placebo test is performed to test the importance of the highway's 2012 opening on local home values. To perform this test, the study's primary dataset is limited to only sales between 2000 and 2011. 2005 is selected as the placebo year. An empty DiD regression model is performed on this new dataset to

determine if there is a significant difference between home values pre-and post-placebo year. The results of this test are described in the following section.

Preliminary Results

The results of the DiD comparison are below.

Group	**Post-Highway Opening** (2012-2019)	**Pre-Highway Opening** (2000-2011)	**Across groups, within time difference**
Treatment (Access to highway)	**A:** Average adjusted home value for treatment homes post-highway opening *$392,082*	**B:** Average adjusted home value for treatment homes pre-highway opening *$364,973*	A – B = Y *$27,109*
Control (No access to highway)	**C:** Average adjusted home value for control homes post-highway opening *$359,892*	**D:** Average adjusted home value for control homes pre-highway opening *$ 369,600*	C – D = Z *-$9,709*
Within time, across groups difference	A - C = W *$32,190*	B – D = X *-$4,628*	Δ *$36,818*

Difference in Differences across time within groups = Y – Z = D1 = $36,818
Difference in Differences within time across groups = W – X = D2 = $36,818
Overall change attributed to highway opening = D1 = D2 = Δ = $36,818

Within the treatment group, homes are worth about $27,000 more post-policy than pre-policy (A-B). This seems to suggest a positive impact of the highway's opening on home values, pending remaining calculations. Within the control group, homes are worth about $10,000 less post-policy than pre-policy (C-D). This negative change is more challenging to explain. It is possible that homes within the control group lost value due to home buyers opting to instead buy in the treatment area for new access to the highway. Without easy highway access in the control group post-highway, homes in this area may have had to lower their prices to attract buyers.

Post-highway, homes in the treatment group are worth about $32,000 more than homes in the control group. This difference is quite large between the two groups and suggests that the highway's opening improved nearby home values, pending remaining differences to be calculated. Pre-highway, homes in the treatment group were worth about $5,000 less than the control group. This is not a very large difference and suggests that the real estate markets between the two were very similar at that time.

Taken together, the estimated change in adjusted home values due to the highway opening is about $37,000. This indicates that due to the opening of the highway, homes close to NC-540 saw an average increase in home values of about $37,000. This result is confirmed with an empty DiD regression model, whose results are presented below. This estimation is without consideration of other home price indicators. The results of this regression are statistically significant, indicating that there is a statistically significant difference in home values in these areas after the highway opening in 2012.

DID Model Results

	Home sales prices, adjusted to 2019 dollars		
Predictors	*Estimates*	*CI*	*p*
Intercept	369600.86 ***	365421.29 – 373780.42	**<0.001**
Post-Highway Opening	-9709.18 ***	-15240.29 – -4178.07	**0.001**
Access to NC-540	-4627.91	-9710.30 – 454.48	0.074
Post-Highway Opening:Access to NC-540	36818.36 ***	30224.66 – 43412.05	**<0.001**
Observations	43894		
R^2 / R^2 adjusted	0.008 / 0.008		

** p<0.05 ** p<0.01 *** p<0.001*

When controlling for home price indicators, the DiD regression model results in a much higher estimated change in home values between control and treatment groups. In this model, the estimated effect of the highway on home values is about $49,000 of additional value. The results of this regression are also statistically significant, again indicating that there is a statistically significant difference in home values in these areas after the highway opening in 2012.

DID Model Results with Control Variables

	Home sales prices, adjusted to 2019 dollars		
Predictors	*Estimates*	*CI*	*p*
Intercept	78103.89 ***	72764.01 – 83443.77	**<0.001**
Post-Highway Opening	-73837.26 ***	-77781.13 – -69893.39	**<0.001**
Access to NC-540	596.70	-1941.76 – 3135.17	0.645
Acreage	15074.57 ***	14010.71 – 16138.43	**<0.001**
Home Age	-4450.83 ***	-4728.25 – -4173.40	**<0.001**
Heated Area	144.72 ***	143.92 – 145.52	**<0.001**
Story Height	-18783.55 ***	-20587.82 – -16979.28	**<0.001**
Post-Highway Opening:Access to NC-540	49145.12 ***	45929.53 – 52360.70	**<0.001**
Observations	43894		
R^2 / R^2 adjusted	0.765 / 0.765		

** p<0.05 ** p<0.01 *** p<0.001*

Finally, the results of the placebo test are presented below. The results show an overall difference of about -$242, a negligible amount in the context of home values. Further, the result is not statistically significant, indicating that there was no significant difference in values in these areas before and after the placebo year (2005). This result emphasizes the robustness of the original DiD results.

DID Placebo Model Results
Placebo year is 2005.

	Home sales prices, adjusted to 2019 dollars		
Predictors	*Estimates*	*CI*	*p*
Intercept	340903.81 ***	333688.16 – 348119.47	**<0.001**
Post-Placebo	44153.78 ***	35203.40 – 53104.16	**<0.001**
Access to NC-540	-6863.57	-15895.93 – 2168.78	0.136
Post-Placebo:Access to NC-540	-241.88	-11287.80 – 10804.05	0.966
Observations	16369		
R^2 / R^2 adjusted	0.016 / 0.016		

** p<0.05 ** p<0.01 *** p<0.001*

Conclusion

Using Differences in Differences and a placebo test, this study has shown that the opening of tolled highway NC-540 resulted in at least $37,000 on average in additional home value for homes within two miles of the highway's intersections. This result is robust, as confirmed by a placebo test. This result contributes to the literature as a unique study of the economic benefit of building a tolled highway.

These results affirm the positive economic effect of a tolled highway on local home values and present a potential revenue stream for state and local governments. However, this study limits this positive effect to homes within two miles of highway entrances. With toll and property tax revenue from such infrastructure, policymakers should consider ways to expand these benefits to more residents, such as through investments in public transit.

This study didn't consider whether other factors may have contributed to the rise in home values. For instance, the influx of new residents to Wake County may have contributed to elevated demand for homes, thus raising home values. Future research should examine the effect of this population change on home values. Additional research is also needed to understand how tolled highways affect home values with varying distances to the highway. Future research should examine the effect of tolled highways on home values across space.

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