Senior Project

Department of Economics

The Value of Highways to Residents of Akron, Ohio

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I. Abstract

Highways provide obvious benefits to the people they serve, allowing them to travel further and faster, but can also prove to be nuisances to those living nearby. Past studies have tried to examine the value of highway proximity by using hedonic housing price models, and I attempt to do the same for Akron, Ohio. Using 2012-2017 home sales data collected from GIS and other physical, neighborhood, and location variables, I seek to examine the effect of highways on housing prices. I use an OLS model with year fixed effects to find that highway distance returns results contradictory of theory and past research. As a result, I run additional regressions on each of the different Akron high school zones to further control for neighborhood effects. These results find that the disamenties of highways dominate at very close distances, while amenity effects are more powerful as distance increases.

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II. Introduction

During the 1950s and 1960s, the highway system in the United States started to develop rapidly. The first big push in this movement began with the Federal-Aid Highway Act of 1956. This bill, signed by President Dwight Eisenhower, created over 40,000 miles of highways as part of the National System of Interstate and Defense Highways, now known as the Interstate Highway System. Although built partially to offer protection in case of attack, these highways are still used extensively by the public and continue to have an impact on people's daily lives. Some argue that highways have contributed to urban sprawl and suburbanization, saying that they decrease the importance of living near employment, thus allowing people to expand further into suburbs. Regardless, highways have effectively changed the way millions of people live. They benefit the public in many ways, allowing people to travel further distances than before while also shortening commute times ("The Interstate Highway System") Because of this, people can more efficiently access their jobs, schools, parks, and other areas of interest and entertainment. Highways, though, do not come without costs. Aside from their often times heavy financial burden, highways often present other problems. Especially for those locating nearby, highways can be a source of noise, visual, and air pollution. While they can alleviate traffic in some ways, highways can also cause congestion near on-ramps, especially during times of heavy use. Highways can also act as barriers in cities, essentially segregating sections of a city and limiting the everyday flow of people.

The people of Akron, Ohio are no exception, and also experience the different benefits and costs that highways bring. On a local scale some of these impacts are much more unique. For example, current City of Akron Planning Director notes that while highways have allowed citizens to enjoy the amenities of different cities and suburbs, it has come at the expense of the downtown Akron neighborhoods. The development of these roads can also cause existing problems to become even worse even worse. In 1963 a “revitalization program” for the city targeted “less desirable neighborhoods as prime location to build an expressway connection…” (Harper, 2015). Years later the plan to build through these neighborhoods has essentially isolated parts of these neighborhoods into several pockets of segregated demographics and income levels. (Harper, 2015). Highways, though, still do provide benefit to Akronites, allowing those who live in Akron to commute to other regions, or others entrance into Akron for work or other purposes.

Because there is reason to believe that highways present both costs and benefits, I would like to further examine how people, specifically of Akron, value these roads. I will use a hedonic pricing method to estimate a willingness to pay in order to research whether highways are amenities, disamenities, or some combination of both to the residents of Akron.

III. Literature Review

Several studies, some using different methods, seek to examine the effect of this impact that highways have on housing prices. Boarnet and Chalermpong (2001) examine the development of a highway system in Orange County, CA in the 1990s. They use hedonic price regressions to see how the construction of a toll-road network changes house prices in nearby areas. They examine three different highways in this network to compare the magnitude of highway impact before and after the highway construction. While a before and after comparison is not relevant to the study of Akron Ohio, the regressions used by Boarnet and Chalermpong provide insight for my model. The OLS model they use includes physical and neighborhood characteristics of the home, as well as a distance variable, and find that house price increases with increasing distance from the highway. They assumed a linear relationship between distance to highways and housing prices, but acknowledge from past literature that the disamenities should dominate at distances less than 1,125 feet. In models based on three different highway segments, all find increasing distance to have a decreasing effect on price, thus suggesting that these highways are amenities.

Other papers assume different relationships between distance and price, in addition to the linear model used by Boarnet and Chalermpong above. Chernobai, Reibel, and Carney (2008) use home sales data from the Los Angeles metropolitan area and use past literature to develop a model in which the non-linearities of the distance variable are accounted for. In doing so, they use a spline regression comprised of 0.4 mile distance increments, and find in most of their models that price reaches a peak at 0.4 miles from the highway, then decrease as distance rises. They also ran a linear distance model and found results consistent with Boarnet and Chalermpong, in that price declines consistently with increasing distance from the highway. While this study also focuses on the before and after impact of a highway extension, the conclusion that positive price effects at shorter distances and negative effects at moderate and increasing distances suggest that highways would be valued differently at varying distances.

Waddell, Berry, and Hock (1993) also use a similar method in their study. While the main focus of their paper looks to establish price gradients to the central business district of Dallas and surrounding nodes of employment, they also examine other factors in their model, such as distance to the nearest highway. They also establish a non-linear relationship between housing price and highway distance by using a slightly different spline regression. Four different distance categories with varying ranges are used for this spline regression: 0-0.25 miles, 0.25-0.5 miles, 0.5-1.0 miles, and 1.0-2.0 miles. They find prices of homes within 0.25 miles of the highway to be depressed by 3.5%, albeit increasing to a positive 2% peak effect within 0.5 miles.

At distances 1-2 miles from the highway, this effect decreases essentially to zero. All distance effects, including those effects of retail, university, and hospital proximity, disappeared at 12-15 miles. They note that this nonlinear pattern is consistent with many of the other amenities examined, where negative externalities outweigh the benefit at immediate distances. These negative externalities include localized noise and air pollution and traffic congestion.

Two more sets of authors seek to find the impact of highways on housing prices, using yet another variation of the hedonic pricing model. Kilpatrick, Throupe, Carruthers, and Krause (2007) use two hedonic models for two different geographical stretches of I-90 highway in Seattle, Washington. One model examines a portion of highway which is tunneled underground, and the other looks at a fifteen mile stretch using home sales observations located in a one-mile band centered on the highway. The model concerning the tunnel suggests that house prices increase at a decreasing rate with distance, almost to a point where the distance is no longer relevant. The model using the above-ground stretch of highway includes both distance to the nearest on-ramp and straight-line distance. The inclusion of the on-ramp distance should reflect accessibility, whereas the straight-line distance should reflect the disamenity effects, such as noise and the physical unpleasantness of locating nearby. Here, the effect of distance to on-ramp is negatively associated with price, while the straight-line distance is positively associated, thus backing up the theoretical expectations.

Allen, Austin and Swaleheen (2015) also use both straight-line distance and on-ramp distance in their spatial lag adjusted OLS models. They examine 1,025 home sales observations up to a distance of nearly one mile from the highway. Using models which also include dummy variables for housing directly adjacent to the highway and dummy variables for neighborhood effects, straight-line distance yields insignificant results while increasing on-ramp distance has a negative effect on house prices. This home price analysis in Orlando, Florida would not support the findings Kilpatrick, Throupe, Carruthers, and Krause in regard to straight-line distance, but would still support them in that increased accessibility, or shorter distance to on-ramps, has a positive impact on house prices.

IV. Theoretical Model

As previous studies have done, this paper will use home sales data in the city of Akron in order to capture the effect of highway distance. The economic theory, as mentioned, is based on the hedonic pricing model, which is a method of estimating demand for an item by breaking it down into its parts and assigning each part a contributory value. As a whole, these values then represent an estimated willingness to pay and demand for housing. For this research, the sales price, or consumer's willingness to pay can in turn can be broken down into its value adding or detracting parts. The following theoretical model, listed below, shows sales price as a function of a home's physical, location, and neighborhood characteristics.

Price = f (physical, location, neighborhood)

Physical characteristics include those variables pertaining to the structure of the building including year built, bedrooms, and bathrooms, among others. Location characteristics may include proximity to places of interest like parks, schools, hospitals, and other sources of entertainment. Neighborhood characteristics may account for other variables such as income levels, crime rates, and school quality.

V. Model Specification

The data I retrieved allows for most of these variables to be included in the empirical model. The majority of data included in this study was made available through databases kept by the City of Akron Geographic Information Systems (GIS). The city updates this information on a regular basis and is extracted from parcel information available through the Summit County Fiscal Office. For parcels of interest, the distance to nearest highway was calculated using a spatial analysis tool in GIS. Other map layers including demographic data from the US Census and Akron Public High School zones were joined to these parcels, using parcel ID as the common key to join physical characteristics and geospatial joins to add high school zone to the data. Each sale for a parcel was stored as an individual observation and after filtering for several factors, 8,827 individual home sales from January 2012 to January 2017 were used for this paper. These observations were filtered to include only single family residential home sales between $1,000 and $1,000,000, in order to eliminate extreme outliers or values which had been entered incorrectly. Also, in an attempt to make sure the data made logical sense, observations with zero rooms and less than 500 square feet of living area were not included in this study.

A one-way year fixed effect is the basic model used in this paper, while a two-way fixed effect for both year and Akron Public High School Zone is also used. The one way fixed effect model is shown below, where *i* = individual home sale, *j* = high school district, and t = year.

$$Y_{i,j,t} = \beta_0 + \gamma_t + \beta_1 Housing_{i,j,t} + \beta_2 Distance_{i,j,t} + \beta_3 MedHHIncome_{i,j,t} + \beta_4 YearDummy_{i,j,t} + \varepsilon_{i,j,t}$$

Variables within *Housing* would include physical characteristics such as year built, bedrooms, bathrooms, acres, and square feet of living area. *Distance* includes a dummy variable for homes adjacent to the highway, as well as distance and distance-squared variable to account for the non-linearities discussed in literature. *MedHHIncome* represents the median household income of a home's census block group, which would not only give us a measure of the neighboring homes, but also should represent higher or lower crime areas. *YearDummy* represents the year in which the sale takes place, which is used to control for any macroeconomic conditions that may vary over the studied time frame.

VI. Results

The one-way year fixed effect model, shown as *Model 1* in the table, uses all of these variables to yield results suggesting that the non-linearities of highway proximities are opposite

Results		
Variable dependent variable: logAdjPrice	**Model 1** Coefficient (t-stat)	**Model 2** Coefficient (t-stat)
YRBLT	0.0111 (30.82)**	0.01010 (27.56)**
logSFLA	0.5936 (15.34)**	0.61069 (15.50)**
logDist	-0.4832 (-4.03)**	-0.04734 (-0.37)
$logDist^2$	0.0363 (4.60)**	0.00459 (0.54)
Adjacent	-0.2415 (-1.95)*	-0.06807 (-0.55)
logMedHHInc	0.7262 (27.64)**	0.60824 (22.10)**
Acres	0.4620 (9.01)**	0.35360 (6.94)**
Bedrooms	-0.0275 (-1.91)*	-0.02269 (-1.60)
Bathrooms	0.2518 (13.44)**	0.21580 (11.67)**
Year Fixed Effects	Yes	Yes
High School Fixed Effects	No	Yes
R^2	0.4536	0.4759
Adjusted R^2	0.4527	0.4745
Number of Observations	8827	8827
Note: ** and *, respectively, denote statistical significance at the 5% (or better) and 10% levels		

of that seen in the literature. All of the other variables in the model return consistent with their expected results. *YRBLT* indicates a house that is one year newer will have a 1.1% higher price. A 1% increase in square feet of living area results in a 0.59% increase in price. For every additional acre a home is located on, price increases 46%. The results suggest that an additional bathroom has one of the largest impacts on house price, increasing it by about 25%. The negative coefficient for bedroom may seem unexpected at first, but suggests that adding a bedroom while keeping square feet constant decreases value because of crowdedness and inefficiency. The household income of the census block group also suggest that higher earning neighbors, which is also associated with lower crime, will increase the price of the home. The distance variables would suggest that contrary to literature using non-linear effects, house price would reach its lowest price at short distances, then increase with increasing distance from the highway. This 'U-shaped' relationship between distance and price beckoned further investigation, so a second model was included with high school fixed effects, based on the eight Akron Public High School zones.

The two-way fixed effect model, shown as *Model 2* in the table, was used in an effort to understand whether highway impact was different among city neighborhoods. Using the high school fixed effect eliminated the significance of several variables, including the main variable of interest, highway distance. One reason for this insignificance may be that the addition of high school fixed effects was unnecessary while already having median household income in the model. Although the income of census block groups are a much more immediate measure of neighborhood effects than the high school zones, there is the potential for high correlation amongst the two, thus a potential cause of the insignificant distance effects. Another reason could stem from the fact that some neighborhoods just tend to be farther away from highways than others. Some of these high school zones are traversed by multiple highways, meaning the majority of houses are relatively close to a highway. Other school zones have only a small segment of highway towards the border, thus resulting in a higher percentage of homes located farther away. This correlation between neighborhoods and distance could also influence results.

Realizing that these correlations may impact the results, I decided to run regressions individually on each of the eight Akron Public High School zones, using the one-way year fixed effect model with each of the same variables as before. The distance variable returned significant in four of the eight high school models. The regression model for Buchtel High School yielded results similar to those for *Model 1*, in that price decreases initially then increases with increasing distance to create a 'U-shaped' relationship. Perhaps this may indicate the strong presence of other transportation substitutes, such as major city roads that are not highways. The other three models for Central, Ellet, and Firestone are all consistent with theory and literature. House

High School Specific Results

Variable dependent variable: logAdjPrice	**Buchtel** Coefficient (t-stat)	**Central**	**Ellet**	**Firestone**
logDist	-2.9084 (-5.42)**	1.7852 (2.42)**	0.8199 (2.47)**	1.5005 (4.65)**
$logDist^2$	0.2107 (5.90)**	-0.1257 (-2.37)**	-0.0501 (-2.30)**	-0.0928 (-4.74)**
Year Fixed Effects	Yes	Yes	Yes	Yes
High School Fixed Effects	No	No	No	No
Critical Distance	994 ft.	1213 ft.	3578 ft.	3244 ft.
R^2	0.4013	0.1687	0.4067	0.5725
Adjusted R^2	0.3938	0.1480	0.3991	0.5679
Number of Observations	1137	579	1102	1309

Note: ** and *, respectively, denote statistical significance at the 5% (or better) and 10% levels

prices, or a consumer's willingness to pay, increases with distance until reaching its peak, then decreases with increasing distance from then on. Using calculus, the critical distance at which price reaches its peak can be calculated and is also shown in the results table. At distances below the critical point for Central, Ellet, and Firestone, noise pollution and other negative externalities of locating close to highways outweigh the benefit which the highway provides, therefore a disamenity. Beyond the critical point, the noise pollution and other negative externalities begin to fade with distance, and the benefits to the customer outweigh the costs, therefore an amenity.

The distance at which house price reaches a max is also consistent with previous studies. Chernobai et al. (2011) and Waddell et al. (1993) find house prices to reach a max around 0.4 and 0.5 miles respectively. The results of the high school specific regressions find that prices reach a max around 0.2 and 0.6 miles, which is very close considering the differences that may exist between this studied cities.

VII. Limitations

As noted in the literature review, studies looking to examine the effect of highways on housing prices all use slightly unique methodologies. Some use a combination of different econometric methods and different variables. All the studies must contain a variable representing distance from the highway, but how distance is defined can have a big impact on the results. Distance can be defined as straight-line distance to the highway or driving distance to the nearest on-ramp. This paper uses straight-line distance, which picks up the more of the negative externalities experienced by homes closer to the highway. Other papers such as those by Kilpatrick et al. (2007) and Allen et al. (2015) use driving distance, which measures more of the accessibility factor as opposed to the negative externalities. Given more time and better knowledge of GIS, it would definitely be beneficial to include driving distance in my model, as well straight-line distance so that both the accessibility and negative externality factors are accounted for. Collecting the current data with only introductory knowledge of GIS was very time consuming, and doing the same thing for every entrance ramp to the highway would've taken much more time and skill.

Another thing I did not include was proximity to other amenities or disamenities of the surrounding area, such as schools, parks, churches, or entertainment venues. While not crucial to my research question, other location factors could play significant roles in a consumer's willingness to pay, in addition to highway proximity. Examples of this could be distance to the central business district, universities, or popular parks. Once again this would require advanced knowledge of GIS and would also add another step to the already lengthy data collection process.

Another limitation is that I left out potentially more accurate neighborhood variables. The US Census data had information on racial composition and vacancy rates for each census block group, but I continued using median household income in the model because it was simpler and theoretically should still be a good representation of the neighborhood quality. It would be expected that lower income areas have higher crime rates, so the fact that I did not have a more accurate crime variable is not detrimental to my study, but more specific crime information could have helped isolate some of the area effects. Because the city of Akron does not have a collective crime database, this collection would have also been very difficult.

VIII. Conclusion

In the initial one-way year fixed effect model, we find results that are quite different from theory and the literature. This city wide model, *Model 1*, finds that highways are viewed as amenities at distances up to 770ft but disamenities for homes located further away. Given that most of the population is not living in such close proximity to a highway, this would suggest that most people in Akron see highways as disamenities. Because the negative effects of highway noise and congestion should fade with distance, more examination was needed. Part of this could be due to the fact that the entirety of neighborhood effects were not picked up by the neighborhood variables. Thus, the distance variable might have also accounted for the fact that nicer neighborhoods tend to be farther from the city center, which also tends to be where highways are highly concentrated. In an attempt to further control for neighborhoods using high school fixed effects, the variables of interest became insignificant. Thus, separate regression models were run on each individual high school zone to isolate the neighborhood impacts. Three of these high school zones yielded results similar to theory in that disamenity effects dominate at close distances, while the benefit of locating closer at distances beyond the critical point increase consumers' willingness to pay.

Knowing the extent to which residents value their highways can offer major implications for the future. While the highway system continues to develop and expand across the United States, some cities have had plans to re-evaluate and even re-structure their highway system. In Boston, a major highway that ran through the heart of the city was rerouted underground. In Seattle, part of the Alaskan Way Viaduct is being removed and replaced with a two-mile underground tunnel. In Milwaukee, parts of an under-utilized and incomplete highway system were removed to create new neighborhoods and free up downtown space (Walker, 2016). As of February 2017, a similar project is underway to remove Akron's OH-59, which was supposed to connect two other major highways but was never completed. Knowing whether or not highways are valuable to residents can impact these decisions immensely. If a highway is a largely a disamenity, its removal, restructuring, or re-evaluation may be beneficial. If a highway is an amenity and its proximity increases the housing value of residents, then construction, expansion, or even continued highway maintenance may be necessary to ensure it continues to benefit the population. Knowing the critical distances can also provide insight on how to best leverage the advantage gained from highways. Overall, studies like these can help cities prevent wasteful allocation of tax dollars, as highway removal and construction can be very costly. This knowledge can help city planners structure better decisions for the future, making cities better and more efficient places to live.

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Appendix A

Variables Used		
Variable	**Description**	**Source**
AdjPrice **(dependent variable)**	Residential, single family home sale price (Jan 2012-Jan 2017) in 2016 dollars.	Summit County Fiscal Office
Acres	Lot size of home (acres).	Summit County Fiscal Office
YearBuilt	Year house was built.	Summit County Fiscal Office
Bedrooms	Number of bedrooms in home.	Summit County Fiscal Office
Bathrooms	Number of bathrooms in home.	Summit County Fiscal Office
SFLA	Square feet of living area in home.	Summit County Fiscal Office
HighwayDist	Distance from centroid of parcel to the nearest highway (feet).	Summit County Fiscal Office, City of Akron GIS
MedHHInc	Median household income of census block group in 2016 dollars.	Summit County Fiscal Office
Adjacent	Dummy variable for homes 150 feet or less from the highway.	City of Akron GIS
YearDummy	Dummy variable representing the year of sale.	Summit County Fiscal Office

Appendix B

Descriptive Statistics					
Variable	**N**	**Mean**	**Std Dev**	**Min**	**Max**
AdjPrice	8827	61081.30	63880.95	1000	1000000
Acres	8827	0.17	0.17	0.02	8.12
YearBuilt	8827	1940	24.53	1843	2015
Bedrooms	8827	2.95	0.71	1	7
Bathrooms	8827	1.42	0.61	0.5	6
SFLA	8827	1350.94	517.69	500	7078
HighwayDist	8827	3938.83	3000.89	22.95	15587.74
MedHHInc	8827	51458.98	18558.93	11498.59	120176.33

Appendix C

Map of Selected Highways and High School Zones