December 2021

Land Rents and Broadband Subsidies

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LAND RENTS AND BROADBAND SUBSIDIES

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
Economics

by
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December 2021

Accepted by:
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ABSTRACT

Is the value of broadband access capitalized in house prices, and do broadband subsidies transfer wealth to targeted subscribers? First, we sample 4995 recent rural Michigan home sales, with their attributes, to calibrate a hedonic model. Our estimation relates housing values to broadband internet access availability, while limiting endogeneity. A second model estimates federal broadband subsidy's effect on availability of 25 Mbps (download) service. Results show a premium between 10-15% in home prices for broadband availability (a potential difference of $15,000-$22,500 with median home price of $150,000), while subsidies appear to not have any significant impact.

ACKNOWLEDGEMENTS

I thank my professors at Clemson: Dr. Templeton, Dr. Barkowski, and Dr. Tamura for all that I have been able to learn from them. I would like to thank Dr. Warren and Dr. Hanssen who both have given much input on my previous papers and this one in particular. I most especially would like to thank Dr. Hazlett for his inspiration and immense help on this thesis. I thank my parents for helping watch my baby girl Abby. I thank Abby for sometimes letting me write and most of all, I thank my wife for letting me do this in the first place.

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CHAPTER I

INTRODUCTION

Wired, high-speed home internet – now commonly used to access school classes, company meetings during "work from home" periods, and conduct business – is more valuable than ever before. This paper seeks to estimate if "broadband" access affects home prices and if so, how can that effect be measured? Secondarily, do programs designed to extend network availability, subscribership, and benefits to lower income rural residents achieve their goals?

Ajit Pai and others at the FCC have been arguing that the lack of availability of broadband in higher cost and lower income areas is an area of great concern. In March of 2010, the National Broadband Plan (NBP) was released, and it stated that there were 100 million Americans without broadband access and that this number needed to be lowered drastically. The NBP set goals for access and availability of broadband, as well as affordability to customers by transitioning the High-Cost Fund component of the Universal Service Fund (USF) – about $4.6 billion per year, almost half of the USF – to the Connect America Fund from what was then for telephone service.[1]

Later, in 2017, Paul de Sa, former chief of the FCC's Office of Strategic Planning and Policy Analysis, estimated that: "As of December 2015, approximately 14% of the approximately 160 million U.S. residential and small-and medium business locations lack access to 25 downstream and 3 upstream Mbps-capable fiber-to-the-premise (FTTP)

[1] https://transition.fcc.gov/national-broadband-plan/national-broadband-plan-executive-summary.pdf

and/or cable service."[2] He also estimated that $40 billion in infrastructure support would bring that down to 2% and that last 2% could be connected for an additional $40 billion.[3]

This study is primarily an application of the hedonic price model, which will be the basis of estimating the effect of broadband availability on house prices. After summarizing the literature on hedonic price models, a thesis is laid out describing what is expected using microeconomic theory. Then several models are estimated that seek to reveal the relationship between fixed broadband availability and housing prices in rural Michigan. From there, an attempt is made to trace out the specific incremental as well as total impact of government subsidies awarded to telecommunications carriers, ostensibly designed to promote broadband buildout in these areas. The first model tests if broadband affects the house price or is "capitalized" by the owners. The second model attempts to estimate the impact of subsidies on broadband availability, in order to see if the subsidies achieve their aims of extending networks to underserved areas. Linking with the first model, the question is raised whether subsidies render benefits, affordability in particular, to lower income residents. The paper then enters a discussion of the results and what the limitations are with the data. From there, ties are made to policy discussion as it relates to broadband effects on housing prices and the linked subsidy efficacy. Finally, suggestions for future research into the topic are discussed.

[2] Megabytes per second (Mbps)
[3] https://fcc.gov/Daily_Releases/Daily_Business/2017/db0119/DOC-343135A1.pdf

CHAPTER II

LITERATURE REVIEW

The overt purpose of High-Cost Fund broadband subsidies is to increase availability and affordability to citizens for internet, particularly for those in rural, insular, and underserved areas by offering service at rates reasonably comparable to urban areas.[4] Greater options for internet, especially in terms of lower quality adjusted price where quality is measured in download and upload speed, latency, and extra amenities, add up to a package of attributes that likely increase the price buyers and renters are willing to pay for housing. How can the impact of this be measured?

The Hedonic Pricing Model

Hedonic – "Relating to or considered in terms of pleasant (or unpleasant) sensations." – Oxford English Dictionary[5]

Court (1939) used utility theory to undergird the hedonic price model. At first it was focused primarily on durables. Later, Griliches (1977), and Rosen (1974) fleshed out the model to its current form and it includes all types of goods and services, i.e., anything that is sold and has utility, especially if it contains multiple heterogeneous streams of utility. Goods and services could also confer disutility. The fundamental idea is that a consumer has a certain willingness to pay for a good or service that has multiple characteristics. Separating the positive or negative value of these individual components

[4] https://www.fcc.gov/general/national-broadband-plan

[5] *Oxford English Dictionary*. https://www.oed.com/ (accessed 3/15/21)

is often advantageous. The hedonic model usually lists the natural log of price as the dependent variable and one or more variables that signify utility as the independent variables. An example hedonic model for an automobile:

$$\begin{aligned} log\ Price = {} & intercept + x\,GASMILEAGE + y\,MAXSPEED \\ & + z\,SAFETYRATING + a\,RELIABILTY + b\,HORSEPOWER \\ & + c\,AIRBAGS(dummy\ variable) + h\,BRAKEASSIST(dummy) \\ & + p\,PASSENGERS + w\,WARRANTYLIFE + u\,AGE \\ & + i\,USED(dummy) + \varepsilon \end{aligned}$$

The hedonic model can incorporate both product and service attributes and market defined variables in determining the price for property. The model is a regression equation, and the choice of independent variables is perhaps different for the seller than for the buyer, but the market clears at the intersection of their respective curves, or schedules of preference at which they would buy or sell the goods in question. As it is, it is a method for isolating values associated with variables of interest in this study, namely the availability of broadband. In this multi-layered analysis, this valuation can then be considered as a cost factor for home buyers – and, by analogy, renters – who receive the "benefit" of broadband subsidies. Where broadband availability is seen to positively impact home prices, the quantification from hedonic pricing models allows the estimation of net benefits delivered to households in areas where broadband networks have been built. In order to determine the effect of broadband, all other potential factors contributing to the value of a home will also have to be accounted for. The following are previous studies that have found how seemingly intangible considerations can be measured using the hedonic price model.

Cavailhès et al. (2009) used advanced geo-spatial methods, specifically satellite imaging, to determine line of site view of farmland in Dijon, France. Hedonic regressions revealed that properties with views of trees have positive effects on price while road views yield negative impact. In Milan, Italy, Mazzocchi et al. (2019) add to the hedonic pricing model of this land from both inside and outside the agricultural sector just outside Milan. They include variables such as climate, soil, type of farm, and diversity of farm output. Bourassa and Peng (1999) look at how feng shui affects the hedonic model. In their paper, they refer to feng shui as a range of attributes that are thought to affect luck in the household. They trace Chinese houses in Auckland, New Zealand and they find that lucky house numbers garner higher values than non-lucky or neutral numbers.

Event Studies

Event studies or exogenous variable shocks as applied to hedonic pricing models are helpful in isolating the effect of a change which makes a good case for causation instead of mere correlation. This method is widely used in real estate price studies (Goodman (1978); Goodman and Thibodeau (2003); Witte et al. (1979)) and tourism and competition (Clewer et al. (1992); Mangion et al. (2005); Taylor (1995)).

Keskin, Dunning, and Watkins (2017) determine the effect of earthquakes and associated risks with real estate values. One finding is that the low end of the market experiences a disproportionately higher detrimental impact on housing values. Pope (2008) shows that the proximity of a house to a registered sex offender will affect homeowners “residing within 0.1 mile, between 0.1 and 0.2 miles, and between a 0.2 and a 0.3 mile radius of a nearby sex offender suffer about 7.0%, 6.0%, and 3.0% property value drops, respectively. These percentage changes translate into $4617.00, $3731.00, and $1897.00 reductions for the average-priced house in the sample, respectively.” Gibbs et al. (2017) look at the externality that arises from having Airbnb listings nearby in large metropolitan cities, one metric that they found interesting – in addition to host characteristics, physical location, and rental characteristics – was that more reviews on a listing were associated with lower prices. This last result was attributed to the likelihood that lower priced listings had more guests due to the lower price. Numerous neighborhood effects have been evaluated for their impact on residential property values, including rail transit stations (Grass (1992), Gatzlaff and Smith (1993); Bowes and Ihlanfeldt (2001); Debrezion et al. (2007)), greenbelts and open spaces (Correll et al., (1978); Bolitzer and Netusil (2000); Irwin (2002); Anderson and West (2006)), brownfields (Kaufman and Cloutier (2006)), airport noise (Espey and Lopez (2000)), churches (Carroll et al. (1996)), and landfills (Reichert et al. (1992)).

Thompson, Butters, and Schmitz (2012) use a before and after effect approach in looking at proximity to places of worship on the price of housing. They call this approach a pre- and post-treatment model. In short, they compare the areas before a temple or church etc. is built before and after and find no effect. They remark that previous research using only post-completion data may over-emphasize the amenity effects of religious structures. Normal business effects result from indirect effects such as taxable base, draws, amenity status, etc. The paper here argues that the church was built in the location as a result of the higher property values and other amenities not the reverse. On the other hand, they cite others who have found that religious institutions have a positive influence on property values such as Do, Wilbur, and Short (1994).

Paolo et al. (2017) study the effect in Venice, Italy of the MOSE project (Electromechanical Experimental Module) which aimed to protect Venice from high tides. The results of the application showed an expected increase in real estate values in the center of Venice where it was deployed, and that the ground-floor apartments especially benefited. A lesson here is that various groups internalize neighborhood effects more than others do based on location and other factors. Also, there is a distributional gain to current owners of the properties that receive the benefits.

Brucal and Lynham (2019) take a nuanced look at how seawalls in California, San Diego and Santa Cruz, affect housing values. Considering the value of protection from the sea as well as potential externalities from the wall itself, there may be costs that are put on to others. While they do not find a significant effect on home values directly protected by seawalls, they do find that seawalls have a significant negative effect on neighboring real estate values in Santa Cruz though in San Diego County. Brucal and Lynham argue that the losses, at least the areas in neighboring Santa Cruz, are associated with accelerated beach loss that the nearby seawalls cause.

The noted advantage from the existence of this extensive literature is in having a solid basis for estimating local exogenous shocks on housing prices. Less extensive, but still helpful, are the few studies that consider the impact of commercial property development on housing prices. Commercial development, transportation, and communications infrastructure clearly seem to have a long-ranging and far-reaching impact in many locales around the country.

Telephone poles, easements, pipelines, nuclear power plants, wind turbines, dams, airports, may be nice if the benefits can be enjoyed and the negative side is outweighed. Distance from the airport or train station has perks as well as headaches if extremely close. Some people may absolutely hate one amenity while others absolutely love it. For example, some may not want 5G boxes in their backyard due to curious fears of cancer while others are clamoring for it in the front because they have no such fears and want the low latency, high bandwidth, and flexibility that such a mobile network provides.

Touching on how residential real estate values are affected by communications infrastructure that perhaps benefits all or most residents, Filippova and Rehm (2007) attempt to determine the impact of proximity to cell towers on property values. They could not find a relationship between cell tower proximity and housing prices except when armed monopole towers were in the area as they are considered unsightly and provide no additional benefit by being in line of sight. Similarly, but with more granularity, Affuso, et al. (2017) use a hedonic spatial model to assess the impact of cell towers on real estate prices. They find that there is only a negative effect on prices if a tower is within 0.78 km of the house. On average, the cost is estimated to be $4,132 per house within that radius, or a negative price effect of 2.65%. Furthermore, if in visible range, the impact is 9.78% more than those not in visible range. This effect vanishes outside the 0.72 km radius. This reality alludes to the benefit of camouflaging towers, piggybacking on billboards, utility poles, water towers, or other existing structures. This problem applies to broadband given the ability of 4G LTE and 5G networks to deliver internet access competing with services supplied by fixed broadband systems.

Broadband

Qiang, Rossotto, and Kimura (2009) highlight the merits of broadband in influencing local economies. Important linkages between broadband availability are found with respect to property values, the number of small businesses, employment levels, and the overall number of firms. Granting that these are indeed goods, and that broadband influences them, we look towards the hedonic pricing model and its use in how broadband affect housing prices.

Molnar, Savage, and Sicker (2019) use a hedonic model to see broadband's effect on housing values. They show that single-family homes in areas with 25 Mbps downstream and 3 Mbps upstream have a sale price of almost $6,000 higher than houses with similar characteristics in otherwise similar neighborhoods than those with 1 Mbps. They are aware of potential endogeneity problems in their estimates and explain that more needs to be done to determine if this price premium is a result or a cause of the broadband access. They even suggest they would eventually use subsidies as an exogenous variable to run a two-stage model. A study in England by Ahlfeldt, Koutroumpis, and Valletti (2014) finds that upgrading from dial-up to 8 Mbps increases English home prices by 2.8%. Interestingly, they find that the effect on rural housing is lower than that of urban. Controls for age and employment are reinforced as determinants of broadband's effect on housing prices by Lai, Widmar, and Bir (2019), who tease out the willingness to pay for higher internet speeds in Indiana on rural broadband. They find age greatly influences how much they are willing to pay in addition to their employment status.

Savage (2018) finds diminishing marginal returns in download speed in his study in Ireland. Using detailed plan-level data, Savage examined the speed and prices of broadband services available to consumers in Ireland over time. While finding modest geographical (county level) variation in broadband services, download and upload speeds have the expected significant effects. Contention ratio (advertised versus delivered speeds) is valued negatively which is also expected. The results indicate a big drop off in the marginal valuation of plans above 60 Mbps.

Lyonsa and Coynea (2013) find that between 2007 and 2013, broadband plans' prices remained the same while quality of service rose significantly, especially in download speed. The key finding, however, was that the price elasticity of demand for download speed and the premium on bundled services decline for most types of broadband plans during the sample period. Also, the price premium that incumbent local exchange carriers enjoyed, fell greatly in the sample period of 2007. This seems to suggest that broadband, as one would expect, had become more essential to consumers as it was also a lower quality-adjusted price, but it also arguably became a more plausible and even indispensable element of the hedonic pricing model as will be discussed later.

CHAPTER III

THEORY

The idea that people value things based on various measurable and even unmeasurable characteristics is represented using the hedonic pricing model. This is essentially a way to determine implicit prices. By forming a linear pricing model which regresses the attributes that people value and differentiating the specific variable in question, there is an attempt to infer its "implicit" price for that variable or attribute in the bundle that is an otherwise composite good, or bundle of goods. In this case, real estate is the good in question. Using various attributes that affect the value to house buyers and sellers (or renters and landlords) and regressing those on the actual purchase price (or rental price) helps to reveal how demand drivers such as floods, nearby infrastructure, local crime, and various subsidies alter market prices. The literature indicates that there is likely a relationship between property values and available broadband access. Using standard theory, subsidies to ISPs would shift their supply curve to the right and would thereby incentivize a greater amount of broadband service for a given retail (subscribership) price.

The thesis is that broadband availability increases the price of housing, holding other relevant factors constant. Broadband subsidies should increase broadband availability. However, if broadband subsidies do affect broadband and broadband access increases rental rates, it would stand to reason that lower income renters would be required to pay the premium which might partly or totally offset the benefits of having the availability.

Does broadband access increase house prices? It is likely that it does. Do subsides to high-cost areas using the High-Cost Fund increase house values with this in mind? It is reasonable to believe that they should. An increase in broadband access should accompany subsidization for areas previously underserved. This increase in access should carry a premium that suggests it is of value which will be capitalized in the house price. Otherwise, it is not just inefficient, but not even appreciated by consumers in proportion to the subsidies they enjoy. If there is capitalization into the price from broadband access, it may have some offsetting effects on the affordability mandate as stated by the NBP.

CHAPTER IV

DATA AND ESTIMATION METHOD

Sample set

This paper obtained house sales data from the state of Michigan, with samples from rural areas mapped on www.Zillow.com.[6] The dataset constructed using his method ranged from February 2018 to March 2021. This state was chosen due to its large rural high-cost areas. There were several appealing rural states such as Alaska, Wyoming, Texas, Idaho, and nine others that forbade listing past sale prices online.[7] Using one state helps control for many factors such as state taxes and state-wide lockdowns etc. The literature on broadband's effect on real estate values generally involved one state or select counties within one state. Due to the rural nature of the areas studied, there should be a relatively homogeneous set of regulations and ordinances. Also, the areas studied appear to have relatively homogeneous demographics.

The process for obtaining the houses was not random in that polygons were drawn in the Zillow.com's map window to limit the houses to 800. This was necessary to obtain houses before 2020.[8] Over 50 maps were drawn around areas that purposefully avoided urban centers. When the houses at this basic list level were obtained, the links were rerun to get the full house-page data which contained all the details available.[9] This process obtained more houses lacking broadband as a result.[10]

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[6] https://www.zillow.com/mi/sold/

[7] *Geo Data Plus*. https://www.geodataplus.com/non-disclosure-states-defined (accessed 7/3/21)

[8] Zillow resets the map and thus the set of houses to be different and reaching further back in time is not possible without this map drawing procedure.

[9] This process was to prevent from being having too many moving parts in the code.

[10] The scraper getting to the end of the list and therefore the older houses was by no means certain, timeouts due to lag or captcha sign in errors were not consistent and therefore limited the end number of observations.

Variables

Following Molnar et al.'s (2019) study on broadband's effect on housing values, the first model features a natural log of the home sale price as the dependent variable. The model takes the natural log of the variables that have a high spread such as square footage and median income. The natural log of square footage is a key control for size of the house and emphasizes the main metric used in real estate to compare neighborhood prices. According to Molnar et al (2019), education level and median income each related almost identically with the model and are therefore interchangeable. The natural log of median income is taken for the census block group and was easier to work with and simpler to include so it was chosen here. Lot size is a key variable which features more in rural houses as they often have more acreage to advertise on Zillow.com. This potentially explains the large proportion of houses lacking broadband in the sample. The hedonic price model will control for year by running a regression for each year. The elementary school ratings score is from Zillow.com's internal mapping software and should be positively associated with housing prices. The model adds the number bedrooms which would be expected to be positively associated with housing price as would number of bathrooms. The presence of a garage is noted by a dummy variable, and it is expected to have a positive coefficient. The estimated taxes paid were only listed on a small percentage of the sample. As a result, Michigan county-level property tax rates are used. Lot size, garage, and geocoding errors reduced the final overall sample size to 4995 houses from over 12,000 initially obtained. While there are measures such as 5G access, sun numbers (home's solar-energy potential), scores for middle and high school, and walkability scores; they were all too rarely posted on Zillow.com as to be included.

Next, we move on from individual housing data to local social and economic characteristics. Median income and the ratio of local households with incomes below the poverty line are compiled by Census Tract and are displayed in the American Community Survey (2017)[11]. Median income should have a positive coefficient while ratio of households below the poverty line should have a negative coefficient. Population density comes from dividing population by the square mileage on Census Block Group from the Decennial Census Data[12]. Population density should have a positive coefficient. County level crime rate is taken from the state of Michigan website[13]. Crime rate should relate negatively with housing price. The data on broadband availability at census block level is relatively granular (one estimate is between 12-60 persons per typical block)[14], and thus represents a fair likelihood that there is coverage in the area in which the house is located. This is taken from the National Broadband Map from the Federal Communications Commission.[15] The prices from Zillow.com are adjusted for inflation by using the Consumer Price Index (CPI) from Federal Reserve Economic Data (FRED)[16], using 2019 as the base year. Below is the comparison of summary statistics for key variables of interest for houses sold in 2018 and 2020, broken out by areas with broadband and without.

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[11] https://www.census.gov/acs/www/data/data-tables-and-tools/ - this was done using an API Key received from the census ACS by census tract

[12] https://www.census.gov/programs-surveys/decennial-census/guidance/2010.html - this was fetched using an API Key as well by block group.

[13] MSP - Statistics & Reports (michigan.go https://www.michigan.gov/msp/0,4643,7-123-1586_3501---,00.htmlv) – This was downloaded by county and merged into the data set.

[14] https://www.census.gov/newsroom/blogs/random-samplings/2011/07/what-are-census-blocks.html, this - The BG is the smallest geographic entity for which the decennial census tabulates and publishes sample data- this number is estimated by dividing the average number of blocks (51) per block group which has between 300 and 1500 on average. Some blocks have no population at all.

[15] https://opendata.fcc.gov/Wireline/Fixed-Broadband-Deployment-Data-December-2019/whue-6pnt) This was done for the three years ending 2017, 2018, and 2019 to represent the status of the Michigan Census Block coverage at the start of the next year.

[16] https://fred.stlouisfed.org/series/CPIAUCSL - this was done by using the base year-2019's CPI and dividing by each of the other year's CPI which then created a multiplication factor to apply to housing values or subsidy dollar amounts.

Table 1.

Variable Values of Houses - Households with Broadband versus Without									
		2018				2020			
Variable	**Broadband**	**Min**	**Median**	**Mean**	**Max**	**Min**	**Median**	**Mean**	**Max**
price	yes	14400	175000	176060	572000	5000	179900	228152	3200000
price	no	7730	131000	166863	3610000	2000	142250	238250	12500000
sqft	yes	832	1600	1730	3800	192	1609	1875	12014
sqft	no	528	1600	1730	4422	360	1527	1853	100000
medianincome	yes					20541	24606	25417	29346
medianincome	no					17821	23499	23284	29346
age	yes	3	43	48	121	1	50	54.16	149
age	no	3	40	45	141	1	48	54.46	153
pop_density	yes	6.72	68.46	229.75	2291.3	3.53	274	853	7363.6
pop_density	no	1.44	20.03	216.65	6369.9	1.34	43.9	648.1	7363.63

The median home price is a good deal lower; about $44,000, or 25.14% in 2018 for houses without broadband availability and about $37,650, or 20.92 % in 2020. Median income is lower as well by about $2000 in areas without broadband. Median population density is also lower in areas without broadband and there were a lot more houses sold from denser areas in 2020 in this study.

Model 1: Fixed Broadband Effect on Price

logPrice = intercept + x ln_sqft + y fixed_broadband + z garage(dummy) + α tax_rate + b age + n elementary_rating + k bedrooms + p bathrooms + g pop_density + u ln_med_incom + c crime_rate + w ratio_in_povert + q lot + ε

Table 2.

Broadband Effect on Log Price					
	Broadband in Place			Broadband Obtained in 2020	
Model	1.1	1.2	1.3	1.4	1.5
Model Year	2018	2019	2020	2019	2020
intercept	9.96	-0.804	-2.521	1.075	6.155**
	[7.19]	[2.596]	[3.033]	[2.788]	[3.16]
ln_sqft	0.80***	0.911***	0.54***	0.894***	0.597***
	[0.15]	[0.085]	[0.069]	[0.095]	[0.089]
fixed_broadband	0.106	0.122***	0.154***	-0.024	0.0487
	[0.105]	[0.058]	[0.052]	[0.061]	[0.067]
garage	0.023	0.213***	0.198*	0.2***	0.2***
	[0.15]	[0.053]	[0.053]	[0.059]	[0.065]
tax rate	-7.04	36.59*	55.8*	-72.44***	-35.5**
	[6.03]	[21.78]	[32.2]	[27.79]	[25.73]
age	-0.005	-0.0041	-0.0044	-0.005	-0.005
	[0.002]	[0.0075]	[0.0007]	[0.001]	[0.001]
elementary rating	-0.024	0.033***	0.015*	0.004	0.004
	[0.016]	[0.009]	[0.0085]	[0.011]	[0.011]
baths	0.111*	0.004	0.158***	0.119***	0.119***
	[0.061]	[0.006]	[0.027]	[0.033]	[0.033]
beds	-0.016	-0.017**	-0.009	-0.006	-0.006
	[0.0579]	[0.0075]	[0.029]	[0.039]	[0.039]
pop_density	-0.00014*	-0.0001***	-0.00002***	-0.0002**	-0.0002**
	[0.000083]	[0.00008]	[0.00007]	[0.00007]	[0.00007]
ln_median_income	-0.42	0.51**	0.935***	0.149	0.149
	[0.71]	[0.26]	[0.29]	[0.319]	[0.319]
crimerate	-187.00	-123.1***	-198.2***	-200***	-200***
	[2130]	[29.5]	[39.7]	[29.57]	[34.96]
ratio_in_poverty	-0.00004	-0.000004**	-0.000004**	0.01	0.009
	[0.000033]	[.000002]	[.000002]	[0.098]	[0.098]
lot	0.223	0.466***	0.203***	0.407***	0.009
	[0.15]	[0.0981]	[0.06]	[0.106]	[0.098]
R squared	0.34	0.47	0.4056	0.52	0.35
Observations	171	704	973	474	615

* *p* = 0.10 ** p = 0.05 *** p = 0.01

Model 1.1, Year: 2018

The first year, 2018, has the lowest number of observations and even less that include the lot size. There is a positive effect, 0.106 of broadband on price, that is, if there is broadband, the price gets a benefit of 10.6 percent on average. This, however, is not statistically significant – see Table 2 column 1.1.

Model 1.2, Year: 2019

This year, 2019, features more house sales data. A positive relationship, of statistically significant magnitude, is seen between the broadband availability dummy and home price. The R^2 also rises – indicating a better fit. Additional variables appear with estimated coefficients of the expected signs, including a positive sign for natural log of square footage, lot size, garage, elementary rating, bedrooms, and natural log of income. It has negative coefficients for age, ratio in poverty, and crime rate. Interestingly, population density, number of bedrooms, and tax are the opposite as would be expected but they are not large. Including lot size eliminated 1100 houses from the 2019 sample (more than half the sample). However, the fixed broadband impact became statistically significant and increased in magnitude to 0.122 for 2019, implying that home prices were 12.2 percent higher in areas where broadband was available. Population density is still statistically significant in effect while it has a negative coefficient. This may be a result from rural clusters potentially being associated with lower income areas versus bigger estates. This effect was in keeping with the literature. This may also have some multi-collinearity with lot size. Big sparsely populated estate areas versus lower income small property regions may also be a factor when larger population centers are not targeted as is the case in this sample – see Table 2 column 1.2.

Model 1.3, Year: 2020

In 2020, there is a highly significant effect on having broadband versus not; there is 15.4 percent effect on price. This broadband coefficient is likely too large due to the lack of variables listed in the observations and perhaps a few other variables linked with broadband and housing. The included variables have the same signs as model 1.2, year 2019, again with tax rate having a positive effect while population density is negative with statistical significance – see Table 2 column 1.3.

Model 1.4, Comparison: Houses sold in 2019 in census blocks without broadband in 2019 then with broadband 2020

This is a subset of the houses sold in 2019. It includes all houses with no broadband in 2019. This model compares houses sold that were in blocks that would get broadband in the next year, 2020. This model checks to see if there is a statistically significant effect of being in the areas that would get broadband the next year, or if they had some unknown attributes that attracted the broadband to the block that would get it in the next year. Was the broadband simply going to the more up and coming areas?

This version shows a negative though non-significant coefficient for the effect of broadband which at least hints that the blocks with no broadband in the first two years did not have some unmeasured advantage which got them the broadband the next year. Since the next year is positive, a sign switch indicates that the model suggests causality and that housing prices were affected by having broadband. The significance of the broadband coefficient here is not strong at a -0.39 t-statistic – see Table 2 column 1.4.

Model 1.5, Comparison: Houses sold in 2020 in census blocks without broadband in 2019 then with broadband in 2020

This is a subset of the houses sold in 2020. It includes all houses with no broadband in 2019. The effect of gaining broadband in 2020 should be positive. Drawing from the pool of houses with no broadband in 2019 that were sold in 2020 and comparing the ones that got broadband in 2020 with those that did not, yields a positive coefficient. Interestingly, this coefficient is close to the effect from other broadband hedonic price model studies, having a coefficient of 0.048, or a 4.8 percent effect on housing price from broadband access. However, this coefficient lacks statistical significance, with a t-statistic being 0.729. The sign change here does suggest there being a causal link between newly achieved fixed broadband access and housing price, though not a significant one – see Table 2 column 1.5.

Model 2: Subsidies

Subsidy data is taken from the Connect America Fund website[16] which lists the yearly and monthly disbursements for the study areas. Study areas are larger than census blocks and therefore they encompass several census blocks.[17] To help mitigate the

[17] *Federal Communication Commission* apps.fcc.gov/edocs_public/attachmatch/DA-94-996A1.pdf. "A study area is a geographical segment of a carrier's telephone operations. Generally, a study area represents a carrier's entire operation within a state. Thus, carriers that operate in more than one state typically have one study area for each state, and carriers that operate in a single state have a single study area. Carriers perform jurisdictional separations at the study area level. For jurisdictional separations purposes, the Commission froze study area boundaries effective November 15, 1984."

distorting effects this may cause, the subsidies were divided either by the number of houses per study area or by the population. Both yield similar results but using houses seemed more reasonable as households are the sites that are getting fixed internet. Subsidies are adjusted for inflation, again using FRED's CPI data. Subsidies are grouped into lagged effects which are grouped in *sub_2018* which covers disbursements from 2018. *Sub_2019* covers 2019, and *sub_2020* accounts for 2020. Incidentally, 2019 saw no subsidies in Michigan according to the data. *Sub_2017* covers 2017, *sub_2016* covers 2016, *sub_2012-15* covers 2012 to 2015, and *sub_2003-11* reaches back to the inception of the fund in 2003 to 2011. Additionally, a variable containing all subsidies per house up to 2020 is used for a separate equation.

Looking at Table 3, one thing that stands out is the relatively high average for subsidies early on for even areas with broadband lacking (as of 2020). Also, the subsidy year with the most significant effect on broadband in 2020 is 2017 which has a relatively low mean for both groups.

Table 3.

Subsidies Per Household - Houses with Broadband versus Without						
Year and Status	**Min**	**1st Quart**	**Median**	**Mean**	**3rd Quart**	**Max**
broadband all yrs, 2003-11	$ -	$ -	$ -	$ 108.51	$ 8.89	$ 2,203.13
broadband no yrs, 2003-11	$ -	$ -	$ -	$ 131.79	$ 8.88	$ 2,203.13
broadband all yrs, 2012-14	$ -	$ -	$ -	$ 44.13	$ 7.80	$ 2,101.99
broadband no yrs, 2012-14	$ -	$ -	$ -	$ 27.66	$ 7.80	$ 396.68
broadband all yrs, 2015-16	$ -	$ -	$ -	$ 9.39	$ -	$ 577.50
broadband no yrs, 2015-16	$ -	$ -	$ -	$ 6.07	$ -	$ 85.13
broadband all yrs, 2017	$ -	$ -	$ -	$ 4.46	$ -	$ 186.18
broadband no yrs, 2017	$ -	$ -	$ -	$ 1.95	$ -	$ 55.00
broadband all yrs, 2018	$ (0.16)	$ -	$ 0.70	$ 0.86	$ -	$ 10.73
broadband no yrs, 2018	$ (0.26)	$ -	$ 0.70	$ 1.48	$ -	$ 38.73
broadband all yrs, 2020	$ -	$ -	$ 6.90	$ 82.96	$ 6.90	$ 1,639.00
broadband no yrs, 2020	$ -	$ -	$ 6.90	$ 86.62	$ 6.90	$ 1,534.00
						*2019 had 0 subsidies

Table 3 has a few interesting results from this study. The similar numbers in a few of the subsidies per household are a result of the subsidies being over study areas while the broadband status is determined at the census block level. There are multiple census blocks within a study area which makes the link between subsidies and census blocks difficult to delineate. This also explains how some blocks can have no broadband while having had high subsidies per household in the study area in several different time periods. Finally, the surge in some study areas in the final year's output of funds is likely tied to the emergency funds related to the COVID-19 pandemic to further buildout broadband infrastructure and maintain availability. The year 2018 also has a minimum subsidy that is negative which refers to carriers having to return funds awarded previously due to failure to complete buildouts promised. The maximum subsidies per house with no broadband is $1,534.00 in 2020 is quite high without achieving broadband in all blocks in the study area.

Table 4.

Subsidy effect on Broadband in 2020				
	All Census Blocks		No Broadband in 2018 Subset	
Model	2.1a	2.1b	2.2a	2.2b
intercept	-10.8***	-10.23***	-3.93***	-3.00*
	[0.90]	[1.351]	[1.13]	[1.69]
Total Subs 2003-2020 per house	-0.00003		-0.00004	
	[0.000019]		[0.00003]	
2020 Subsidies per house		0.0001***		0.0001***
		[0.00004]		[0.00005]
2018 Subsidies per house		0.001		0.0001
		[0.003]		[0.00005]
2017 Subsidies per house		0.024***		0.027***
		[0.004]		[0.004]
2015-2016 Subs per house		-0.008***		-0.007***
		[0.002]		[0.002]
2012-2014 Subs per house		0.0003		0.005**
		[0.0004]		[0.002]
2003-2011 Subs per house		-0.0005***		-0.0013***
		[0.00005]		[0.0003]
pop_density	0.00007***	0.00006**	-0.00004	-0.00004
	[0.00003]	[0.00002]	[0.000037]	[0.00003]
lot	-0.006*	-0.079***	-0.122*	-0.106**
	[0.002]	[0.031]	[0.06]	[0.04]
ln_median_income	1.13***	1.047***	1.173***	0.34**
	[0.09]	[0.134]	[0.132]	[0.15]
crime_rate	-50.81***	-50.46***	-21.8***	-21.46***
	[9.77]	[9.546]	[12.47]	[12.23]
R squared	0.07	0.11	0.03	0.06
Observations	2132	2132	1460	1460
		* p = 0.10	** p = 0.05	*** p = 0.01

Model 2.1a and 2.1b, Subsidy effect on census block broadband

This is a simple model that relates the lagged subsidy effects to the broadband status which is a dummy of 1 if it has 25 Mbps download, 3 Mbps upload or more Mbps download speed for the census block. Subsidies for 2019 are omitted as they were not disbursed that year for Michigan according to the National Broadband Map. This model also uses a few applicable neighborhood characteristics from the hedonic model with broadband status as the dependent variable: lot size (*lot*), population density (*pop_density*), crime rate (*crimrerate*), and the natural log of median income (*ln_med_income)* are independent variables in addition to the subsidy variables.

Model 2.1b uses the lagged effects and shows no consistent relationship between subsidies and broadband access. 2.1a shows a slightly negative though not statistically significant effect for total subsidies disbursed on broadband penetration on 2020 census blocks. Median income also has the expected positive coefficient with an expected negative value for crime rate. Lot size and population density also have negative coefficients which is expected – see Table 4, Models 2.1a and 2.1b.

Model 2.2a and 2.2b, Subsidy effect on 2020 broadband availability in census blocks without broadband in 2018

These last two models echo Model 1.5 in using only the set of census blocks that did not have broadband in 2018. The regression looks at the effect of having subsidies on those blocks and what potential effect it had on their likelihood of getting fixed broadband by 2020. It is not a large change but seems to indicate that there is more of a difference when comparing former compatriots that lack broadband in 2018 than when comparing the whole sample. The total subsidy coefficient in Model 2.2a becomes more negative, -0.00003 to -0.00004. This seems to indicate that subsidies since 2018 have not been more successful in achieving broadband access in 2020 as the coefficient became more negative – see Table 4, Models 2.2a and 2.2b.

CHAPTER V

OBSERVATION/DISCUSSION

There appears to be plausible evidence that broadband availability is correlated with the price of housing from Model 1 when controlling most of the hedonic variables established in the literature. While the coefficients of broadband availability on price may be biased upward, they at least capture the direction. In turn, as per the goal of subsidies, it does not seem that subsidies make a consistently positive impact on the broadband penetration in the sample.

In their reevaluation of the effect of broadband access and speed on housing prices, Molnar, Scott, and Sicker (2019) use other neighborhood characteristics that are associated with deployment of broadband which also seem to increase property values. Share of nonwhite population is associated with lower home prices. Population age, education attainment, and housing density are all associated with higher home prices as well as broadband penetration. Polynomial variables for Road and Road squared suggest that the value of a house declines with road density at a decreasing rate. Bedrock is associated with lower home prices. In contrast, a higher geographical area of the neighborhood, and a higher percentage of wetlands are both associated with increasing price. These attributes were not used in this study which helps explain the large coefficients for broadband availability.

Why might it be that subsidies do not increase broadband availability? Hazlett and Wallsten (2013) argue that "unsubsidized markets have already made mobile broadband service available to 98.5% of U.S. households, cable TV systems (virtually all of which provide broadband connections) pass more than 99.3% of households, and companies offer digital subscriber line (DSL) service in 97% of rural areas." Above, Paul de Sa estimated that it would take an additional $40 billion for broadband buildout for the last 2 percent of unserved areas. These last few percentage points are difficult to finish off and require significant expenditures per potential subscriber. Hazlett and Wallsten suggest that the amount in subsidies could be saved and spent on satellite subscriptions for the small percentage of rural Americans still without fixed broadband access and it would thereby represent a large increase in social welfare. Hazlett and Muñoz (2009) further argue that opening and auctioning off satellite spectrum from inefficient uses would increase the quality and lower the cost of satellite in general and likely obviate the need for remote fixed broadband altogether.

Molnar and Savage (2017) find that wireline speeds are often higher in markets with two or more wireline internet service providers (ISPs) than just one. Belloc et al. (2012) echo this about competition but offer that it is true in the first and second stage but may change with more subsidies in a later stage, as efficient firms that did not require subsidies are inefficiently pushed out, thereby raising costs in terms of subsidies for redundant line coverage as well as lost competition. They also argue that demand-side policies have more effect on broadband penetration than supply-side interventions. They argue that a mix of different strategies is important and changing technologies will make it a continually changing game.

While this study does not reveal a relationship generally between subsidies and broadband access there are potentially pockets of impact, and the nature of the impact would provide much grist for analysis. Ciaian et al. (2021) review the extensive literature on the capitalization of agricultural subsidies into land prices. They state that generally when land supply is inelastic that the subsidies are capitalized into prices. The share or incidence of subsidies between renter and owner depends on how the subsidies are implemented, on local institutions, and on spatial effects. As with agricultural subsidies, broadband subsidies involve various mechanisms, timing, announcements of fund disbursements, and announcements of buildouts which means that their commencement would potentially affect who got the appreciated value conferred by the announced or completed buildout. A buyer of land that just so happened to buy right before an announcement of the disbursement of broadband subsidies or imminent buildout may receive a windfall while those that rent may just see an increase in the rental rate. Lower prices comparable to urban areas would confer an amenity to the house user due to the support subsidies. Residents obtaining these lower prices could also incur the added cost if they were required to pay extra for that amenity (as the case would be for a renter, or someone looking to buy at that point). On the other side, the landlord would receive the capitalization of broadband's effect on their property's value. This may be in the form of rents in both the colloquial usage and sense that comes from economist's use in the term rent-seeking.[18] If it were the case that broadband subsidies created rents for absentee landlords or upper income rural residents, it would question the notion as to why these subsidies are deemed so important when other methods could give access to lower income people in high-cost areas.

[18] *Oxford English Dictionary*. https://www.oed.com/ (accessed 3/15/21
"an attempt to obtain economic rent (i.e., the portion of income paid to a factor of production in excess of what is needed to keep it employed in its current use) by manipulating the social or political environment in which economic activities occur, rather than by creating new wealth."

As for mechanisms for subsidies, Goolsbee (2002) argues that with the willingness to pay for fixed broadband being relatively low while the cost is relatively high in rural areas, that "a natural approach to increasing broadband usage is to subsidize each user directly. Such a subsidy is restricted to those markets in which such service exists. The problem with providing such a subsidy is that people not currently subscribing to broadband service at the market price are precisely the people who do not value it highly enough to subscribe. In markets in which the service already exists, those who do not purchase it are simply indicating that their valuation does not exceed, say, $40 a month."

This paper could benefit from having more observations that did not fall out when adding lot size. Pool and fireplace are two variables not included from the Zillow.com data. For simplicity, several factors were not included from the FCC: the number of providers, their respective speeds and types of delivery such as fiber, fixed wireless, and DSL. The several omitted neighborhood characteristics that correlate positively with broadband availability and housing prices also likely bias the broadband coefficient to be higher. The national broadband map has many criticisms and there are many attempts to improve the accuracy and granularity of the data on census block internet coverage.[19] The study area subsidies from the FCC database are not tied to census blocks but to study areas and those encompass several blocks and may not be precise or granular enough to capture whether the blocks tied to the houses in the sample are indeed the blocks getting the subsidies. The use of the houses per study area goes a good way towards helping with this issue but it still does not measure what goes into overhead for carriers and builders and what reaches the end user in the form of lower rates and better access. Obtaining data

[19] https://www.benton.org/blog/congress-tells-fcc-fix-broadband-maps-now -for example, only 1 house needs to have access in a block for the block to be considered served at that speed. (using multiple providers, speeds, and types of service can help make the status of availability more reasonably accurate)

from paid real estate data sources or large data firms could produce more data with more options for variables. For obtaining higher coverage accuracy, running the home addresses though a program that checks to see what internet providers serve them could show current coverage to compare with the National Broadband Map. With subsidy disbursement, it would be a matter of getting detailed information from companies themselves along with statements and announcement by the carriers and the FCC.

In addition to improved granularity in both broadband access and subsidy disbursement, much work needs to be done to tease out who benefits from the subsidies: renters, carriers, owners, or a mixture of the three. Also, the timing of announcements of funding and buildouts of broadband infrastructure and the resulting prices of houses would provide telling information from those on the ground. More and more, the effects of LTE, 5G, and improved satellite technology all could reduce or erase the fixed broadband (as currently defined) premium on house prices.

CHAPTER VI

CONCLUSION

The use of hedonic models here estimated a broadband effect of between 10.6 and 15.4 percent on the housing prices. This range is certainly too high to represent the true effect. This is likely explained by the lack of variables that correlate with more broadband penetration and higher prices in the model from Molnar et al. (2019) discussed above. Either way, there is evidence here that broadband positively correlates with housing price based on this sample though the causation is not definite in this study. The comparison of houses sold in 2019 and 2020 using the subset of houses having no broadband in 2019 suggests a method for using an exogenous shock to tease out a causal link. If this effect is causal, then broadband availability is capitalized in the price which may negatively affect affordability or at least offset the benefits that the amenity of broadband gives to renters.

The effect of subsidies on broadband penetration seems reasonable in theory but the sample fails to show a consistent positive relationship. From this study, there does seem to be a hint of overkill in some areas and lack of buildouts in other areas. The effect of total subsidies per house up to 2020 on broadband availability has negative coefficient with no statistical significance so the result of subsidies impacting broadband availability is mixed or at least the jury is still out. Some areas may indeed benefit from subsidies to broadband with broadband availability being increased but the amount in subsidies disbursed over areas without it is indicative of less than an ideal use of funds.

BIBLIOGRAPHY

Affuso, Ermano; Cummings, J. Reid; Le, Huubin . *Wireless Towers and Home Values: An Alternative Valuation Approach Using a Spatial Econometric Analysis.* The Journal of Real Estate Finance and Economics. 653–676. 2017.

Ahlfeldt, Gabriel; Koutroumpis, Pantelis ; and Tommaso Valletti. *Speed 2.0: Evaluating access to universal digital highways*. 2014.

Anderson, S.E., and S.E. West. (2006). *Open Space, Residential Property Values, and Spatial Context*. Regional Science and Urban Economics 36:6, 773-789.

Arlan ; Lynham, John, Coastal armoring and sinking property values: the case of seawalls in California. Environmental economics and policy studies, 2021-01-01, Vol.23 (1), p.55-77.

Ayan, Ebubekir, & Erkin, H. Cenk, Hedonic Modeling for a Growing Housing Market: Valua Apartments in Complexes. International Journal of Economics and Finance; Vol. 6, No. 3; 2014.

Belloc, Filippo; Nicita, Antonio; Rossi , Maria Alessandra. Whither policy design for broadband penetration? Evidence from 30 OECD countries. Telecommunications Policy Volume 36, Issue 5, June 2012, Pages 382-398

Bolitzer, B., and N.R. Netusil. (2000). The Impact of Open Spaces on Property Values in Portland, Oregon. Journal of Environmental Management 59:3, 185-193.

Bourassa, Steven; Peng, Vincent. Hedonic Prices and House Numbers: Influence of Feng Shui. International Real Estate Review Vol. 2. No 1: pp. 70-93. 1999.

Bowes, D.R., and K.R. Ihlanfeldt. (2001). Identifying the Impacts of Rail Transit Stations on Residential Property Values. Journal of Urban Economics 50:1, 1-25.

Boxall, P.C., W.H. Chan, and M.L. McMillan. (2005). The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Analysis.

Brucal1, Arlan ; Lynham, John. Coastal armoring and sinking property values: the case of seawalls in California. Environmental Economics and Policy Studies (2021) 23:55–77

Carroll, T.M., Clauretie, T.M. & Jensen, J. Living next to godliness: Residential property values and churches. *J Real Estate Finan Econ* 12, 319–330 (1996). https://doi.org/10.1007/BF00127540

Carroll, T.M., T.M. Clauretie, and J. Jensen. (1996). Living Next to Godliness: Residential Property Values and Churches. Journal of Real Estate Finance and Economics 12:3, 319-330.

Cavailhès, Jean; Brossard , Thierry; Foltête, Jean-Christophe; Hilal, Mohamed; Joly, Daniel; Tourneux, François-Pierre; Tritz, Céline; Wavresky, Pierre. GIS-Based Hedonic Pricing of Landscape. Environ Resource Econ 44:571–590. 2009.

Census Bureau. https://www.census.gov/

Ciaian, Pavel & Baldoni, Edoardo & Kancs, d'Artis & Drabik, Dusan. (2021). The Capitalization of Agricultural Subsidies into Land Prices. Annual Review of Resource Economics. 13. 10.1146/annurev-resource-102020-100625.

Clewer, A.; Pack, A.; Sinclair, M.T, Johnson, and Thomas, 1992. Price competitiveness and inclusive tour holidays in European cities. Choice and demand in tourism. pp.123-143 ref.27. 1992

Correll, M.R., J.H. Lillydahl, and L.D. Singell. (1978). The Effects of Greenbelts on Residential Property Values: Some Findings on the Political Economy of Open Space. Land Economics 54:2, 207-217.

Court, A.T. Hedonic price indexes with automotive examples The Dynamics of Automobile Demand, General Motors, New York p. 98–119. 1939.

Coynea, Bryan; Lyonsa, Sean. The price of broadband quality: tracking the changing valuation of service characteristics, 26th European Regional Conference of the International Telecommunications Society (ITS): "What Next for European Telecommunications?", Madrid, Spain, 24th-27th June, 2015, International Telecommunications Society (ITS), Calgary. 2015.

Debrezion, G., E. Pels, and P. Rietveld. (2007). The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-analysis. Journal of Real EstateFinance and Economics 35:2, 161-180.

Do, A.Q., Wilbur, R.W. & Short, J.L. An empirical examination of the externalities of neighborhood churches on housing values. *J Real Estate Finan Econ* 9, 127–136 (1994). https://doi.org/10.1007/BF01099971

E-*school News* https://www.eschoolnews.com/1999/01/01/slc-becomes-part-of-universal-service-administrative-co/ (accessed 7/6/21)

Espey, M., and H. Lopez. (2000). The Impact of Airport Noise and Proximity on Residential Property Values. Growth and Change 31:3, 408-419

Federal Communication Commission. Universal Service Fund https://www.fcc.gov/general/connect-america-fund-caf

Federal Communication Commission. Universal Service Fund. https://www.fcc.gov/general/universal-service-fund

Federal Communication Commission. National Broadband Map https://broadbanda.cc.gov/#/about

Feinerman, E., I. Finkelshtain, and I. Kan. (2004). On a Political Solution to the NIMBY Conflict. American Economic Review 94:1, 369-381

Filippova, Olga; Rehm, Michael (2007) The impact of proximity to cell phone towers on residential property values. International Journal of Housing Markets and Analysis Vol. 4 No. 3, 2011. pp. 244-267. Department of Property, The University of Auckland, Auckland, New Zealand.

Firth, Lucy; Mellor, David. Broadband: benefits and problems. Telecommunications Policy Volume 29, Issues 2–3, March–April 2005, Pages 223-236. 2018.

Gatzlaff, D.H., and M.T. Smith. (1993). The Impact of Miami Metrorail on the Value of Residences near Station Locations. Land Economics 69:1, 54-66.

Geo Data Plus. https://www.geodataplus.com/non-disclosure-states-defined (accessed 7/3/21)

Goodman, Allen C. Hedonic prices, price indices and housing markets, Journal of Urban Economics, Volume 5, Issue 4, 1978, Pages 471-484, ISSN 0094-1190, https://doi.org/10.1016/0094-1190(78)90004-9.

Goodman, Allen C.; Thibodeau, Thomas G. Housing market segmentation and hedonic prediction accuracy. *Journal of Housing Economics*, Volume 12, Issue 3, 2003, Pages 181-201, ISSN 1051-1377, https://doi.org/10.1016/S1051-1377(03)00031-7.

Goolsbee, Austan. "Subsidies, the value of broadband, and the importance of fixed costs." *Broadband: should we regulate high-speed internet access* (2002): 278-294.

Grass, R.G. The estimation of residential property values around transit station sites in Washington, D.C.. *J Econ Finan* 16, 139–146 (1992). https://doi.org/10.1007/BF02920114

Gibbs, Guttentag, Gretzel, Morton, and Goodwill. Pricing in the sharing economy: a hedonic pricing model applied to Airbnb listings, Journal of Travel & Tourism Marketing, 35:1 46-56.

Griliches, Z. Price Indexes and Quality Change: Studies in New Methods of Measurement, Harvard Univ. Press, Cambridge. 1971.

Hazlett, Thomas W., and Scott J. Wallsten. Unrepentant Policy Failure: Universal Service Subsidies in Voice & Broadband. *Arlington Economics*. January 2013.

Hazlett, Thomas, W., and Roberto E. Muñoz. A welfare analysis of spectrum allocation policies. The Rand Journal of Economics. 21 July 2009. https://doi.org/10.1111/j.1756-2171.2009.00072.x-283

Herriges, J.A., S. Secchi, and B.A. Babcock. (2005). Living with Hogs in Iowa: The Impact of Livestock Facilities on Rural Residential Property Values. Land Economics 81:4, 530-545.

Irwin, E.G. (2002). The Effects of Open Spaces on Residential Property Values. Land Economics 78:4, 465-480.

Kaufman, D.A., and N.R. Cloutier. (2006). The Impact of Small Brownfields and Greenspaces on Residential Property Values. Journal of Real Estate Finance and Economics 33:1, 19-30.

Keskin, Berna; Dunning, Richard, Watkins, Craig. Modelling the impact of earthquake activity on real estate values: a multi-level approach. Journal of European Real Estate Research. ISSN: 1753-9269. 2017.

Kiel, K.A., and M. Williams. (2007). The Impact of Superfund Sites on Local Property Values: Are All Sites the Same? Journal of Urban Economics 61:1, 170-192.

Kirwan, Barrett E. "The Incidence of U.S. Agricultural Subsidies on Farmland Rental Rates." *Journal of Political Economy* 117, no. 1 (2009): 138-64. Accessed August 13, 2021. doi:10.1086/598688

Lai, John; Widmar, and Bir (2019) Eliciting Consumer Willingness to Pay for Home Internet Service: Closing the Digital Divide in the State of Indiana. Article in Applied Economic Perspectives and Policy. DOI: 10.1002/aepp.13000. 2020.

Mangion, Marie-Louise; Durbarry, Ramesh; Sinclair, M. Thea. Tourism Competitiveness: Price and Quality. https://doi.org/10.5367/0000000053297202. Volume: 11 issue: 1, pages: 45-68. 2005.

Mazzocchi, Chiara; Federica, Monaco; Borghi, Anna; Gaviglio, Anna ; Eugenio, Rosalia Filippini, Demartini, Guido Sali. Land rent values determinants: a Hedonic Pricing approach at local scale AESTIMUM 75. 235-255. 2019.

Molnar, Gabor. and Savage, S.J.Market Structure and Broadband Internet Quality. J Ind Econ, 65: 73-104. https://doi.org/10.1111/joie.12106. 2017

Molnar, Gabor, Scott J. Savage & Douglas C. Sicker (2019) High Speed Internet access and housing values, Applied Economics, 51:55, 5923-5936, DOI: 10.1080/00036846.2019.1631443

Mossberger, Karen ; Caroline J. Tolbert, Ramona S. McNeal. Digital Citizenship. The Internet, Society, and Participation, 2007.
National Telecommunications and Information Administration. https://www.ntia.doc.gov/category/national-broadband-availability-map (accessed 7/6/21)

Oxford English Dictionary. https://www.oed.com/ (accessed 3/15/21)

Pope, Jaren C. Fear of crime and housing prices: Household reactions to sex offender registries, Journal of Urban Economics, Volume 64, Issue 3, ISSN 0094-1190, https://doi.org/10.1016/j.jue.2008.07.001. Pages 601-614. 2008.

Qiang, Rossotto, and Kimura. Information and Communications for Development Extending Reach and Increasing Impact. The World Bank. 2009.

Reichert, A.K., M. Small, and S. Mohanty. (1992). The Impact of Landfills on Residential Property Values. Journal of Real Estate Research 7:3, 297-314.

Rosato, Paolo ; Breil, Margaretha ; Giupponi, Carlo ; Berto, Raul (2017), Assessing the Impact of Urban Improvements on Housing Values: A Hedonic Pricing and Multi-Attribute Analysis Model for the Historic Centre of Venice. Buildings (Basel), 2017-11-30, Vol.7 (4), p.112.

Rosen, Sherwin. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. Journal of Political Economy Volume 82, Number 1. 1974.

Rosston, Gregory L, and Bradley S. Wimmer. The 'state' of universal service. Information Economics and Policy Volume 12, Issue 3, September 2000, Pages 261

Schively, C. (2007). Understanding the NIMBY and LULU Phenomena: Reassessing Our Knowledge Base and Informing Future Research. Journal of Planning Literature 21:3, 255-266.

Scott, Savage; and Sicker. Reevaluating the Broadband Bonus: Evidence from Neighborhood Access to Fiber and United States Housing Prices. 2015.

Song, Y., and G.-J. Knaap. (2003). New Urbanism and Housing Values: A Disaggregate Assessment. Journal of Urban Economics 54:2, 218-238.

Taylor, George. The community approach: does it really work? Tourism Management, Volume 16, ISSN 0261-5177, https://doi.org/10.1016/0261-5177(95)00078-3. Pages 487-489. 1995.

Taxrates.org. http://www.tax-rates.org/michigan/property- . (accessed July 3, 2021)

Thompson, Eric; Butters, Roger; Schmitz, Benjamin. The Property Value Premium of a Place of Worship. Contemporary Economic Policy. Volume30, Issue. Pages 215-222. 2012.

United States Administration Company. https://apps.usac.org/hc/tools/disbursements/default.aspx (Accessed 4/1421)

Wallsten, Scott J. 2017. "Rural Broadband Subsidy Programs are a Failure. We Need to Fix Them." The

Zillow.com. https://www.zillow.com/homes/michigan_rb/. Extracted from February 15-March 31, 2021