The Internet and the Housing Market: The spillover effect of the digital divide on home buyers

Ravi Joshi*

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Abstract

I study the effect of broadband access on the price and availability of mortgage credit.The results of my study suggest that with the increase in broadband access the interest rate decreases while the loan amount increases. I also analyze whether the broadband usage will increase the competition among the mortgage lenders but find no support for this idea. I describe several mechanisms that could be driving the results. Overall, my results shed light on the correlation between broadband access and the housing market.

*Louisiana State University, rjosh15@lsu.edu, 2925 Business Education Complex North, Baton Rouge, 70803.
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1 Introduction

Widespread Internet penetration is associated with several benefits Ghosh (2017), but it has also introduced a tremendous digital divide Armenta et al. (2012) that may change the housing market in the long run — the people having access to internet will find better options to choose the online lenders as opposed to those without internet access.

In this paper, I explore the effect of broadband availability on the loan to value ratio and on the interest rate in the mortgage market. This is an important research question because the explosive growth of technology in this decade has increased the options for people who are shopping around to get the best loan to value ratio and the best mortgage rates. Traditionally, before the technological revolution, people used to go to the local lenders or to the banks when applying for loans. The growth in technology has contributed to easy flow of the information to the people who have access to internet. The information transfer by the use of technology such as internet has resulted in information asymmetry among the people who have access to high speed broadband and those who don't have the access.There has been a rapid increase in the number of online lenders and there are more shopping opportunities now because of the ease in flow of information by internet. The the home buyers always look for the best lenders to get a competitive interest rate and the loan amount while lenders face competition because of the increase in demand.

My study is related to the supply demand question of economics: the increase in access to broadband will increase consumer demand that may increase the competition for the suppliers (lending agencies). The increase in supply-demand will only benefit the home buyers having broadband access. In a long run, the people without broadband access will eventually be kicked out of the housing market as the use of technology increases and the local lenders face increased competition from outside lenders. The local lenders will not be able to match the loan to value or the

interest rates provided by the lenders present in the online platform and because of the decrease in the demand of local lenders they will eventually be kicked out of the business.

The mortgage market is particularly an interesting part of my study because of its extensive coverage in the US households. The HMDA data is publicly available and can be combined with other data sources such as the US Census data, FCC Data, Microsoft research data on broadband penetration and usage and several other public data sets. There are several public agencies that comment on the accuracy of the FCC data form 477 but this data has been used in previous studies to explore the broadband penetration in the United States. There are other sources of broadband availability data such as the CPS and ACS survey, but they also depend on FCC data for broadband availability statistics in the United States.

In order to study the effect of broadband penetration on the housing market I combine the data from HMDA, FCC Form 477, US Census Bureau demographics data, Microsoft research data on broadband penetration and usage, and Freddie and Fannie data to map the FICO score of each applicant applying for mortgage. For my empirical work, I employ the OLS estimation taking into account the year and the county as the fixed effects.I have also tried to look for the exogenous shocks that may be affecting my results but I was unable to explore these factors because of the lack of sufficient data. I have taken the control variables , available in my sample data, that are not correlated in order to remove endogenity issue, however, some bias may still be seen . I also look into the effects of broadband penetration on home buyers based on demographics and socio-economic factors and my results are significant.

There have been a few other studies that explore the impact of internet access on the property value. One such study has been done by the researchers Ahlfeldt et al. (2017).

To the best of my knowledge, my study is one of the first studies to document the relationship between the Internet and the housing market using a large-scale

data set. My research is different from the previous research done in the area of housing market and the internet usage. In my study, I explore the effect of the broadband penetration on the loan to value ratio and the interest rate that home buyers get when they apply for mortgage while the past research such as Ahlfeldt et al. (2017) explores the effect of broadband penetration on the property value ex-ante. My research findings should be of interest to an ongoing academic effort in order to explore the effect of broadband penetration on the housing market once HMDA releases more data.

This paper is divided into four sections. Section 2 includes a literature review section and my motivation for the research. Section 3 includes a discussion of the sources of data, sample construction, and summary of key variables. Section 4 includes the empirical analysis and results of the study. Section 5 provides the conclusion of this paper.

2 Literature Review

The literature that motivated me to do this kind of study is related to the evaluation of broadband demand and to the benefits associated with Internet deployment. At a macro level, Czernich et al. (2011), using a panel of OECD countries, estimate a positive effect that Internet infrastructure has on economic growth.Kolko (2012) also finds a positive relationship between broadband expansion and local growth with the US data, whereas Forman et al. (2012) study whether the Internet affects regional wage inequality. Greenstein and McDevitt (2011) provide benchmark estimates of the economic value created by broadband Internet in the United States. Some studies assess the demand for residential broadband:Goolsbee (2006) use survey data on individuals' earnings and time spent on the Internet, whereasNevo et al. (2016) employ high-frequency broadband usage data.

The study that is specifically interesting to me is the paper "Speed 2.0: Evaluating Access to Universal Digital Highways" by Ahlfeldt et al. (2017) . In this paper, the researchers argue that it is possible to infer the value brought by a faster Internet connection via changes in property prices. Broadband availability and speed embody just one characteristic of a property that contributes to determining its value (along with local amenities, infrastructure, and other neighborhood characteristics). In 2012, The Daily Telegraph, a major UK daily newspaper, reported the results of a survey among 2,000 homeowners, showing that a fast connection is one of the most important factors sought by prospective buyers. The article states that "[...] a good connection speed can add 5 percent to a property's value". The primary aim of the empirical strategy that researchers are using is to provide a causal estimate of the impact of high-speed broadband supply on house prices. The empirical challenge in estimating this causal effect is to separate the effect of broadband supply from other unobserved and potentially correlated determinants of house prices. In particular, the researchers try to ensure that there are no omitted variables that simultaneously determine broadband supply and house prices. The researchers argue that robust identification can be achieved from discontinuous variation in speed over time. Variation over time helps disentangle the effect of broadband supply from unobserved (spatially) correlated locational factors. The researchers further place properties into groups that are near to and share the same broadband coverage boundary to control for shocks at a very small spatial level. They argue that variation in speed over time across a broadband boundary within such a small area is plausibly exogenous and as good as random. Conditional on shocks to a certain broadband catchment area—such as a sudden increase in income or education of the local population—within- same broadband penetration area- variation in speed over time that results from the distance of a property from the relevant exchange can be assumed to be exogenous.

Overall, this paper evaluates the extent to which broadband speed is capitalized into house prices. The researchers estimate consumer surplus associated with broad-

band Internet speed by using micro data on property prices in England between 1995 and 2010. They find a 3 percent elasticity of property prices with respect to speed at the mean of the speed distribution in their data. Because of significant diminishing returns to speed, this elasticity applies only to marginal changes and properties with average Internet connections. Upgrading a property from a normal (8 Mbit/s) to a fast (24 Mbit/s) connection increases the value, on average, by 1 percent. This is still a large effect.

My study is similar to the literature review that I have presented above but my research focuses on the initial interest rate and the initial loan to value ratio that people get while applying for a mortgage as opposed to the studyAhlfeldt et al. (2017) in which the future property value is affected by the broadband penetration when people are selling the properties.

3 Data and Sample Construction

To examine the link between Internet penetration, usage and its effects on housing market I combine detailed data from various official sources including the Federal Communications Commission (FCC), the U.S. Census Bureau, the Home Mortgage Disclosure Act (HMDA) and the Microsoft research broadband data. Broadband penetration data come from the FCC county level data (2008-2018), the broadband usage data by county (2019-2020) comes from Microsoft Internet usage data. I restrict my empirical focus to the years 2018–2020 because HMDA started to provide the interest rate for each transaction from 2018 and the broadband usage data provided by Microsoft research is available from 2019 onwards.

Data on broadband availability comes from FCC Form 477, which reports the number of broadband providers offering broadband services at 200 kilobits per second or faster in a ZIP code. The FCC data is the only comprehensive indicator of U.S. broadband availability that has been recorded annually since 1999 (Kolko 2010b) and

is extensively used by policy makers and academics to assess broadband availability (California Public Utilities Commission 2006; Grubesic 2008; Kolko 2012; Seamans and Zhu 2014; Xiao and Orazem 2011). The FCC Form 477 broadband penetration data is also available by county from 2008-2018 and FCC updates the data biannually (June and December). I have taken the mid-year data from FCC because it accurately reflects the average broadband penetration for the entire year. As noted in past literature, the use of the FCC data to measure broadband availability may introduce measurement error for certain study contexts (Greenstein and Mazzeo 2006; GAO 2006, 2009; Kolko (2010); Xiao and Orazem 2011). For example, there may be business but not residential subscribers in a given ZIP code, so the FCC's count will overstate residential broadband availability. This estimation problem was in the FCC data that was collected before 2018 but after 2018 FCC started providing the correct broadband availability/1000 people so in preparing the data I have ruled out the problem of overestimation or underestimation by filtering out the FCC data that was collected before 2018.

I combine U.S. Census Bureau and the broadband availability FCC and Microsoft research data to account for various demographic and socioeconomic factors that allow me to control for social and economic factors across locations. The U.S. Census provides the county-level information on population density, age proportions, race proportions, number of people below the poverty line, employment level, median household income, and size of the population in a county. These demographic and socioeconomic factors are important to control the characteristics that influence the mortgage interest rates in general and the overall housing market.

Data on housing market comes from the Home Mortgage Disclosure Act (HMDA) that is available on individual level. HMDA data is the most comprehensive source of publicly available information on the U.S. mortgage market, and the only publicly available source of nationwide application-level data on the supply and demand for mortgage credit. I have the HMDA data from 2018-2020 and I have filtered the data

based on action taken, property type, lien status, business or commercial purpose and occupancy status. As HMDA does not have the individual credit score so I merged HMDA data with Freddie and Fannie data to map credit score of each home buyer for each transaction. I have taken credit score, first payment date,occupancy status,combined LTV,original DTI ratio,original unpaid balance,original LTV,postal code,loan purpose, original loan term,original interest rate,property type,loan sequence number from Freddie data and I have filtered the data based on the first payment date after 2018. I have created a key in the Freddie data that contains First payment date, postal code, original unpaid balance ,original loan term, purpose, property value, and interest rate. I repeat the process for Fannie data and finally merged Freddie and Fannie data sets on the key. The final data maps the broadband availability in the corresponding county and the HMDA data for each home buyer. The broadband availability in a county is assigned to the households living in that county because it is assumed that all the households in a particular county will have the same access to the broadband. I have taken the census data for 2020 as the 2019 data as the complete data for 2020 has not been made publicly available as of now.

Microsoft research data is available publicly and contains broadband penetration and usage data over the years 2018-2020. This data is important because the broadband speed for this data is over 25 MBPS and the data has broadband county-level usage as well. The usage data is not available in FCC or on other websites and the Microsoft broadband usage data is available for the years 2019-2020.

The important variables to study the effects of broadband penetration on the interest rate or the loan amount are the broadband penetration, broadband usage,broadband unused, interest rate, Credit Score, applicant income, loan to value ratio, debt to income ratio, change in broadband penetration, race and ethnicity, differential interest rate, and the number of agencies providing loan. The change in broadband penetration is an important variable in my study that reflects the change in internet penetration over the years 2018-2020. In order to find the impact

of broadband penetration on different socio-economic groups I have segmented the data based on the income range and the race and ethnicity of the applicants applying for the home loan. In order to sort the data based on income range I have taken income between (30000-62000) USD for low income groups and the income in the range (135000-300000)USD for the high income groups. The reason for taking 62000 USD and 135000 USD is that these numbers fall in 1^{st} and 3^{rd} Quartile respectively and the data becomes more representative.

Fig 1 provides broadband penetration in the United States from 2016-2020 as provided by FCC.

Figure 2 presents the normal density plot over histogram. The figure shows that the higher density of broadband penetration lies in the range 0.6-0.8. The broadband penetration data is for each county in the United States over the years 2009-2018.

Figure 3 presents the map of United states that shows the broadband penetration distribution per county for the year 2020. This map helps us to identify the counties having higher broadband penetration from the counties with lower broadband penetration.

Figure 4 presents the map showing the change in broadband penetration over the years 2018-2020.

[Insert Fig 1, Fig 2, Fig3 and Fig 4 here]

3.1 Sample Description Statistics

Table 1 reports the household level statistics for the key variables that we use in our analysis. I have a total of 3244624 observations to do the analysis for the individual household transactions. The panel reports summary statistics for the outcome variables. I have taken the range of credit score from 620-850 because this makes the data more representative for the applicants getting the loan approval. The applicant

income varies from (30,000- 300,000) USD, the loan amount varies from (50,000-700,000) USD, the maximum property value is 2,000,000 USD, the debt-to-income ratio varies from (5-70) and the loan to value ratio varies from (20-120). The race and ethnicity sample contains Asians, White, Blacks, Hispanic or Latino, American Indian or Alaska Native, and Hawaiian or other Pacific Islander. The percentage change in broadband penetration over the years 2018-2020 is calculated to plot the counties in the US map that have change of more than 60% . I have created abs-interest variable that is constructed by taking the absolute value of the difference between the interest rate and the median value of interest rate for each year. The mean credit score in our sample is 753.1 with the standard deviation of 45.3, the mean monthly income in our sample is 104,748 USD, the mean broadband penetration for years 2018,2019 and 2020 is 0.8 whereas the mean penetration for years 2008-2018 is 0.65. The mean of the broadband usage by county for the years 2018-2020 is 0.3, the reason for the low mean is the unavailability of broadband usage in 2018 as provided by Microsoft research. The mean loan size in our sample is 254091 USD, the mean interest rate is 3.7, the mean debt to income ratio is 34.5, and the loan to value ratio is 74.7. I impute the purchase price based on our calculation of loan to value ratio at origination. Overall, my data shows that there is an increase in the broadband penetration in the United States over the years, and in the next section I create empirical models to find the relationship between broadband penetration and the controls that affect the housing market.

[Insert Table 1 here]

4 Empirical strategy

I estimate the impact of broadband penetration on the interest rate and the loan amount that home buyers get when they apply for mortgage for the years 2018-2020

by the design:

$$Y_{ct} = \alpha + \beta \times X + \gamma \mathbf{Z} + \mu_c + \mu_y + \epsilon_{ct} \tag{1}$$

where Y_{ct} is the interest rate or the amount of loan for each home buyer in county c in year t, X is the broadband penetration in county c , and vector Z includes county-level house price, debt to income ratio, credit score of each home buyer and all other controls that are historically known to affect the interest rate or the amount of loan. County fixed effects, μ_c, capture county-level time-invariant unobservable factors such as the access to education, cultural and social beliefs that can promote or hinder the use of technology or internet. Year fixed effects, μ_y, absorb time-specific shocks.

The coefficient of interest, β, captures the effect of broadband penetration on the interest rate . A positive β would suggest that the interest rate increases for home buyers having higher broadband penetration than those having low county level broadband penetration. In general, I would like to see β go in the negative direction for the interest rate with the increase in the broadband penetration while β should go in the positive direction for loan amount.

5 Empirical Results

The first set of results (section 5.1) shows that increase in broadband penetration and usage decreases the mortgage interest rate, while the increase in broadband penetration and usage is positively correlated with the loan amount. The second result (section 5.2) shows that high income blacks get the best interest rate while low income blacks get the worst interest rates even for the similar broadband penetration.There will always be an endogenity issue in this kind of study and it is tough to completely eliminate the endogenity issue.

5.1 Impact of controls on the housing market variables

The broadband penetration and the usage may affect the mortgage interest rate. In order to find this relationship,I take the interest rate as a dependent variable and Broadband Usage, Credit Score, Original Debt to Income Ratio and log(Applicant Income) as the controls and use year and county fixed effect. The control broadband unused is the percentage of people not using broadband at all even though there is a broadband penetration in their county. This is an important control because it shows the impact of not using broadband in the interest rate. The results as shown in the Table 2 suggest that the coefficient β for broadband usage is -0.141,the β for broadband penetration is 0.025 and the β for broadband unused is 0.106.The results suggest that the broadband usage has significant effect on the interest rate and the people who do not use broadband despite having the penetration in their county get a higher interest rate compared to other groups. My results are significant as seen by the p values.

[Insert Table 2 here]

In order to find out the effect of broadband penetration on the loan amount , I ran the OLS regression taking the loan to value as dependent variable and broadband penetration , credit score, debt to income ratio and poverty percentage as the controls and use year and county fixed effect. The regression results in the Table 3 suggest that as the broadband penetration goes up the loan to value goes up by a factor of 0.569 for univariate regression and by a factor of 0.464 for the regression in which controls are added.The broadband usage has a significant effect on loan to value ratio as seen my β (5.547) and (4.732).Broadband usage tells the percentage of population that is using broadband to access online platform in the housing market. The control broadband unused is the percentage of people not using broadband at all even though there is a broadband penetration in their county. This is an important

control because it shows the impact of not using broadband in the loan amount.The β (-4.476) for broadband unused shows that this control has an impact on loan to value ratio. The controls in this regression model are independent so we can ignore that simultaneity bias is affecting our results, however it is tough to rule out endogenity. This result further substantiates my theory that I have formulated.

[Insert Table 3]

In order to find the relationship between the number of unique loans per lender and the broadband usage in a particular county I run the regression of the panel data from year (2018-2020) in which the dependent variable is the number of unique loans and the controls are broadband usage and poverty percentage. The results as presented in Table 4 suggest that the increase in broadband usage may increase the loans provided by the lending agencies. This result also suggests that competition between the home loan agencies may increase with the increase in broadband usage as suggested by the coefficientβ (21.398) in the regression result. This implies that people will have better access to the loans provided by lenders and as the lenders face competition the interest rate drops.I have taken county and year fixed effect for this regression.

[Insert Table 4 here]

In order to find out the actual change in interest rate with the change in broadband penetration, I have created a variable *interestrate- medianinterestrate* and regressed the absolute value of this variable against controls such as broadband usage, broadband penetration, credit score and debt to income ratio. The results of the regression are presented in Table 5 and the β(-0.055) suggests that the increase in the broadband usage reduces the interest rates.I have also added the Broad-

band penetration as the control to find out the difference in results for the two groups– one having broadband access and other using broadband .The usage tells us the percentage of people who are using the broadband in a particular county.The β(-0.055) tells us that broadband usage affects the interest rate more than the penetration β (-0.004). I use county id and year fixed effect and the results are significant.

[Insert Table 5 here]

5.1.1 Empirical analysis based on demographics and the socio-economic factors

In this section, I analyze the data based on the demographics (race and ethnicity) and socio-economic factors(Applicant Income) of the home buyers. I regress the differential interest rate on the broadband usage,credit score and debt to income ratio of home buyers taking year as the fixed effect. The data suggests that the interest rate of high income group Asians decreases β(-0.061) with the increase in broadband penetration and the interest rate of low income group blacks decreases β (-0.006) with the increase in broadband penetration. In general the interest rate decreases for all groups with the increase in broadband penetration as we can observe by β factor of all groups in the regression results.The interest rate that low income blacks get with the increase in broadband usage is worst among all other races β (-0.006) while the interest rate that high income blacks get is the best β (-0.126). Asians get the best interest rate β (-0.158) while Blacks get the worst interest rate β (0.056). The results are presented in Table 6 and Table 7.

[Insert Table 6 and Table 7 here]

5.1.2 Empirical analysis based on the change in interest rate for the years 2018-2020

In this section, I analyze the change in the internet penetration over the three years (2018-2020). This data corresponds to the county-level changes in the United States. I regress the interest rate (dependent variable) with the broadband penetration, Credit Score, and DTI ratio for each year separately taking county and year fixed effect. The results presented in Table 8 show that there is a positive relationship (0.018) between the interest rate and the internet penetration for the year 2018 but for the years 2019 (-0.170) and 2020 (-0.044) there is a negative relationship, the reason being that for the years 2019 and 2020 the broadband speed is greater than 25MBPS while for the year 2018 the broadband speed is greater than 200 kbps. These results further suggest that the people who have faster internet connections get a better interest rate as compared to the ones having a slower connection. The results are based on 480,795 observations for 2018, 640,551 observations for 2019 and 1,289,822 observations for the year 2020. Overall, the results are significant as suggested by p values.

[Insert Table 8 here]

6 Conclusion

In this study, I find out the impact of broadband usage and penetration on the housing market. Results of my study suggest that as the broadband penetration increases the loan to value ratio increases and the interest rate decreases.I have also done the analysis based on the race and ethnicity of the people applying for mortgage. Overall, my results show that broadband penetration affects the loan to

value ratio and the interest rates when people apply for mortgage. The broadband usage has higher impact on the housing market than broadband penetration.The results also show that the Asians get the best interest rates and the Blacks get the worst interest rates for the same level of broadband penetration. There will always be endogeneity issue involved and I will explore this issue further.

This research can be extended further once FCC and HMDA release more data and I will explore more to have a better understanding of the effect of broadband penetration and usage on the housing market.

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Figure 1: Broadband Penetration in US 2016-2020

This figure plots the internet penetration in the United States.There is 27.45 percent increase in broadband penetration over the years.

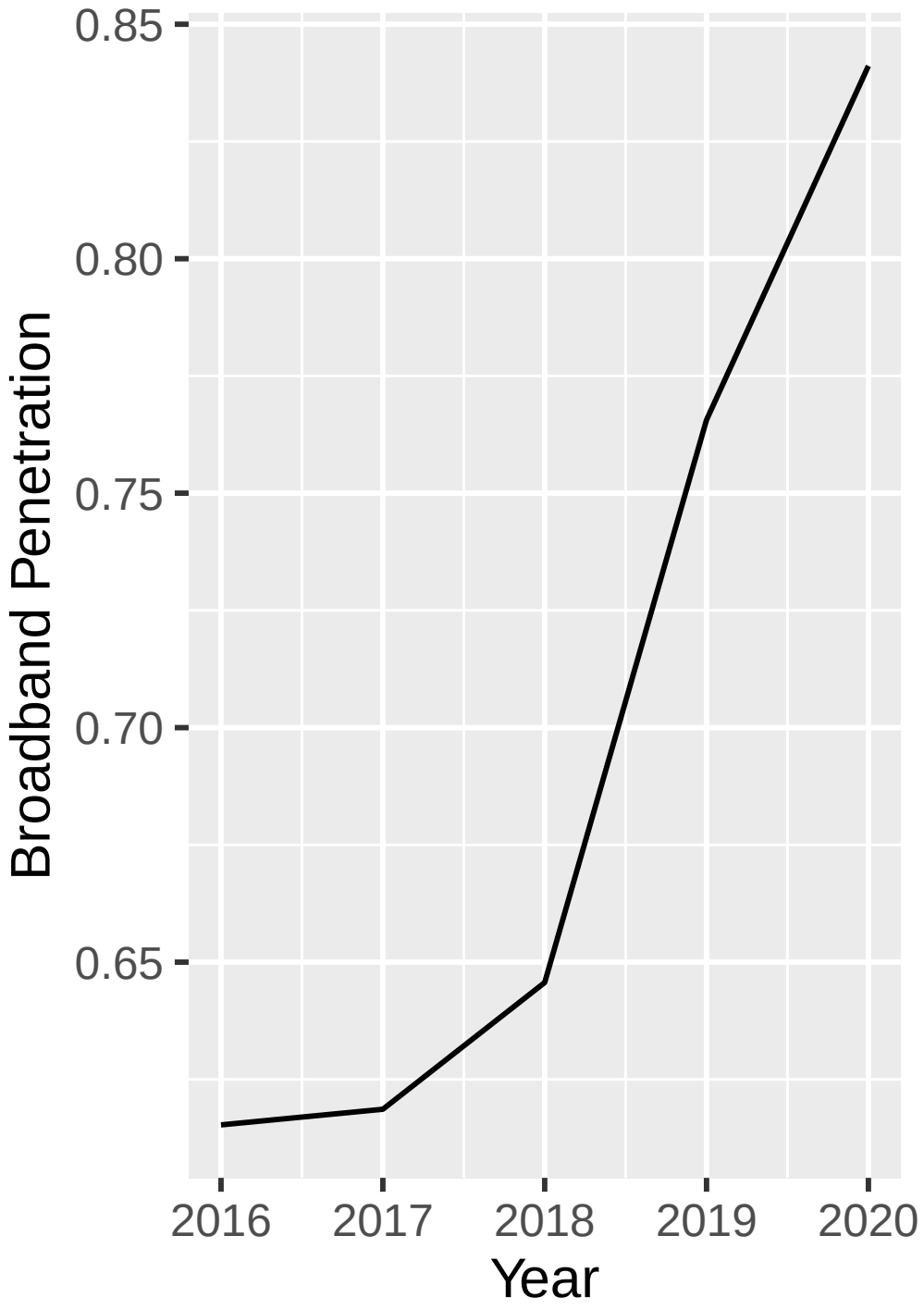

Figure 2: Normal Density over Histogram

This figure plots the normal density curve for the broadband penetration in United States over the years 2009-2018. The highest density of broadband penetration lies in the range of 0.6-0.8

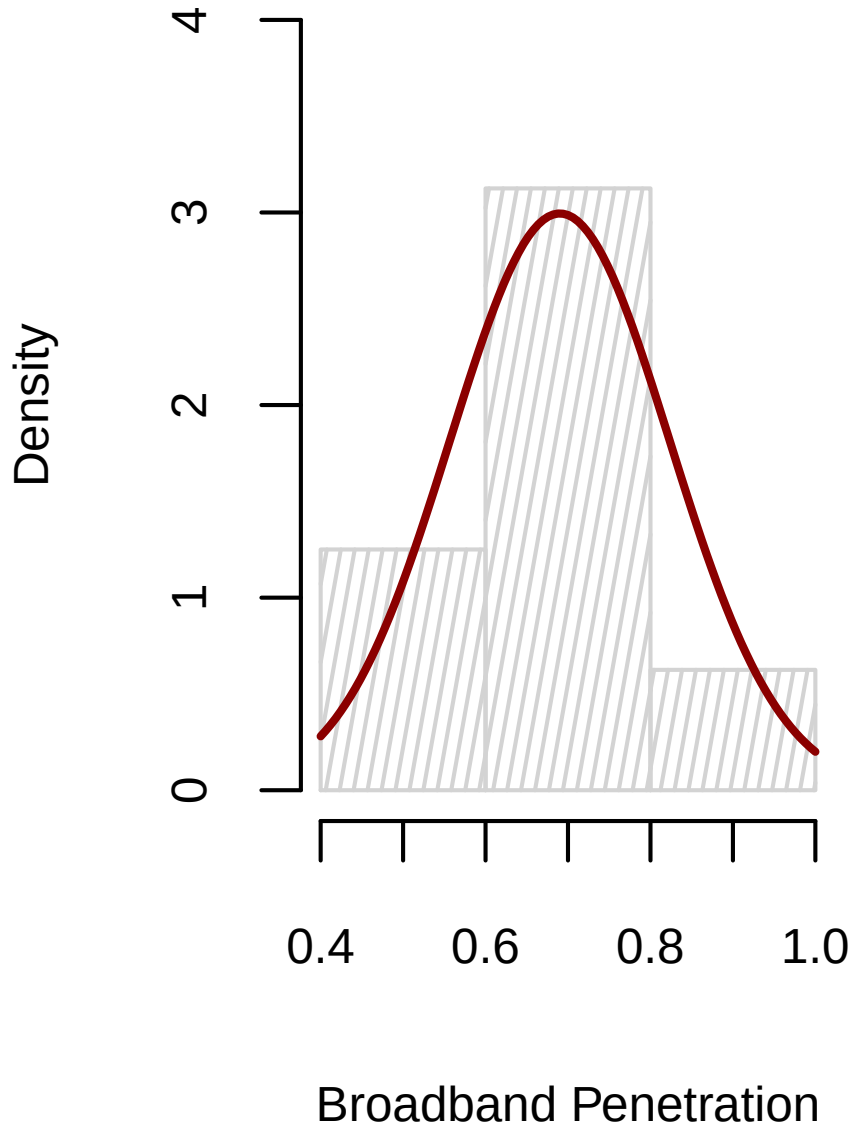

Figure 3: 2020 Broadband Penetration

This figure represents the broadband penetration in the United States in 2020.The green color represents the counties with less than 25% penetration while the magenta color represents the counties having more than 50% penetration.

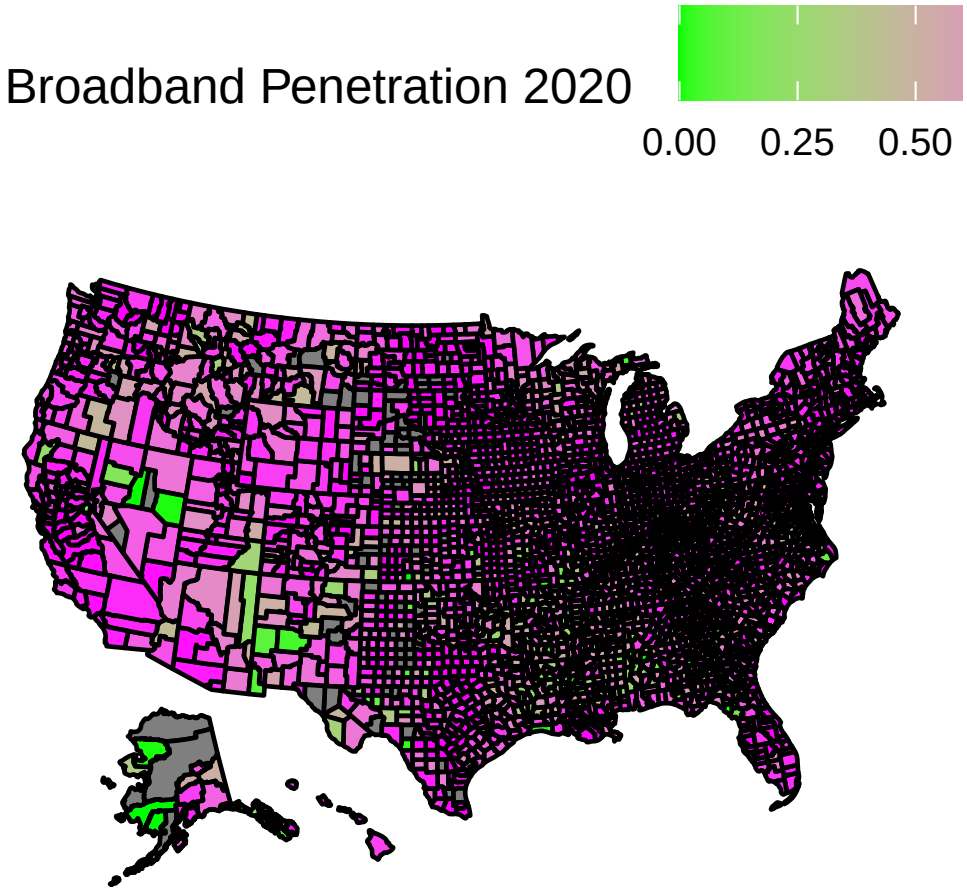

Figure 4: Percent broadband change (2018-2020) >60%

This figure plots the map showing the counties having more than 60% change in broadband penetration. The majority of counties that reflect this change are in Texas while one county shown in magenta is in New Mexico that has 712% change

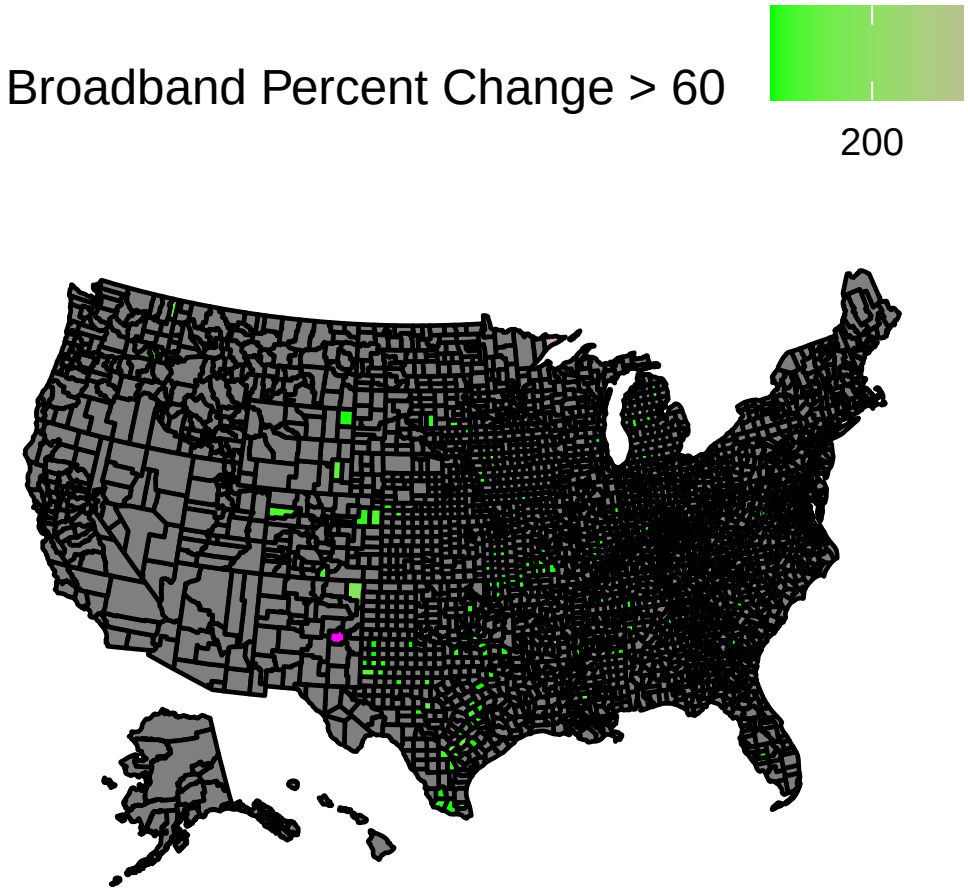

Table 1: Summary Statistics:
This table reports the results of the summary statistics of the variables that affect the housing market. There are 3095992 observations and the data is for the years 2018,2019 and 2020. The original source of data is HMDA that is available publicly.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Credit Score	2,413,114	753.5	45.1	620	723	791	839
ApplicantIncome	2,413,114	103,303.0	52,368.1	30,000	63,000	131,000	300,000
Loan Amount	2,413,114	249,957.9	124,887.9	50,000	150,000	330,000	700,000
Interest Rate	2,413,114	3.7	0.8	1.8	3.1	4.4	6.9
Diff_Interest(mean)	2,413,114	0.005	0.8	−2.0	−0.6	0.6	3.1
Debt to Income	2,413,114	34.4	9.5	5	27	42	61
Diff_interest(median)	2,413,114	0.1	0.8	−1.9	−0.5	0.8	3.2
Loan to Value	2,413,114	74.9	15.4	20	66	85	113
Property Value	2,413,114	350,065.8	175,771.0	55,000	225,000	445,000	1,975,000
Year	2,413,114	2,019.3	0.8	2,018	2,019	2,020	2,020

Table 2: Regression Results
This table reports the results of regression to find the effect of Broadband Usage and Broadband Penetration on Interest Rate.For regression results presented in column(1) I have added the controls Credit Score, Debt to Income ratio and log(Applicant Income) to the Broadband Usage while on column (2) the regression is univariate with Broadband penetration as the only control. Column 3 has the control "Broadband Unused" that represents the people who have broadband penetration in their county but are not using the broadband. I use county and year fixed effect. The β of Broadband Unused is highest and positive. This shows that the people who do not use broadband at all get the highest interest rate among all other groups.I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:			
	Interest Rate			
	(1)	(2)	(3)	(4)
Broadband Usage	-0.141*** (0.010)			
Broadband Unused			0.106*** (0.009)	0.079*** (0.010)
Credit Score	-0.378*** (0.001)		-0.378*** (0.001)	
Debt to Income	0.003*** (0.00004)		0.003*** (0.00004)	
log(Applicant Income)	-0.089*** (0.001)		-0.089*** (0.001)	
Broadband Penetration		0.025*** (0.003)		
Observations	1,930,433	2,413,114	1,926,389	1,926,389
R^2	0.500	0.583	0.500	0.429
Adjusted R^2	0.499	0.582	0.499	0.428
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3: Regression Results
This table reports the results regression to find the effect of Broadband Penetration and Usage on Loan to value Ratio.For OLS regression results presented in column(1), column (2) and column(3) the regression is univariate with Broadband Penetration, Broadband Usage and Broadband Unused as the only control. Columns 4 and Columns 5 follow the same approach with Credit Score, debt to income ratio and Poverty Percentage as the controls. The results indicate that there is a positive impact of broadband penetration on Loan to Value ratio. The impact of broadband usage is much more then broadband penetration and the β factor suggests that the use of broadband significantly increases loan to value ratio.The β(-4.476) for unused broadband suggests that people who do not use internet despite broadband penetration in their county get lower loan amount compared to other groups. The results suggest that broadband usage increases the loan amount for mortgage. I use county and year fixed effect. I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:				
	Loan to Value				
	(1)	(2)	(3)	(4)	(5)
Broadband Penetration	0.569*** (0.087)			0.464*** (0.085)	
Broadband Usage		5.547*** (0.326)			4.732*** (0.320)
Broadband Unused			-4.476*** (0.292)		
Credit Score				-2.575*** (0.022)	-3.005*** (0.025)
Debt to Income				0.251*** (0.001)	0.254*** (0.001)
Poverty Percentage				-0.066*** (0.020)	
Observations	2,413,114	1,930,433	1,926,389	2,413,114	1,930,433
R^2	0.048	0.049	0.049	0.081	0.085
Adjusted R^2	0.047	0.048	0.048	0.080	0.084
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 4: Regression Results
This table reports the results of regression to find the effect of Broadband Usage on the number of unique loans provided per lender.I use county and year fixed effect. I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:
	Unique Loan
Broadband Usage Population	21.398*** (3.098)
Observations	6,081
R^2	0.958
Adjusted R^2	0.915
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 5: Regression Results
This table reports the results regression to find the impact of Broadband Usage and Penetration on the absolute value of interest rate. From the regression results broadband usage has higher impact on the interest rate as compared to the broadband penetration and the results further substantiate that the broadband usage affects the interest rate.I use county and year fixed effect. I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:	
	|Interest-Median Interest|	
	(1)	(2)
Broadband Usage	-0.055*** (0.007)	
Broadband Penetration		-0.004** (0.002)
Credit Score	-0.185*** (0.001)	-0.174*** (0.0005)
Debt to Income	0.057*** (0.003)	0.042*** (0.002)
log (ApplicantIncome)	-0.010*** (0.001)	-0.003*** (0.0005)
Observations	1,929,974	2,411,168
R^2	0.075	0.070
Adjusted R^2	0.073	0.069
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 6: Regression Results

This table reports the results regression to find the impact of Broadband Usage on the absolute value of interest rate based on socio-economic conditions such as Income and Race. Broadband Usage that reflects the percentage of people using the broadband per county. From the regression results we can see that high income blacks benefit the most from broadband usage while low income blacks benefit the least in getting the interest rate with same change in broadband usage.I use county and year fixed effect. I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:			
	|Interest Rate-Median|			
	Low Black (1)	High Black (2)	Low Asian (3)	High Asian (4)
Broadband Usage	-0.006(0.088)	-0.126(0.094)	-0.079(0.068)	-0.061(0.040)
Credit Score	-0.239*** (0.006)	-0.221*** (0.007)	-0.119*** (0.005)	-0.066*** (0.004)
Debt to Income	0.038(0.040)	0.157*** (0.035)	0.050(0.032)	0.066*** (0.016)
Observations	21,176	14,669	20,986	46,075
R^2	0.147	0.147	0.089	0.051
Adjusted R^2	0.094	0.095	0.036	0.034
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 7: Regression Results
This table reports the regression results to find the interest rate variation among different races.I use county and year fixed effect.Asians get the best interest rate while Blacks get the worst interest rate. I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:
	Interest Rate
Broadband Usage	-0.143*** (0.010)
American Indian or Alaska Native	0.014(0.012)
Asian	-0.158*** (0.010)
Black or African American	0.056*** (0.010)
Native Hawaiian or Other Pacific Islander	0.020(0.013)
White	0.012(0.010)
Credit Score	-0.372*** (0.001)
Debt to Income	0.005*** (0.00004)
Observations	1,930,433
R^2	0.500
Adjusted R^2	0.499
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 8: Regression Results
This table reports the regression results to find the impact of Broadband Percentage on the interest rate for the years 2018-2020. The columns are 2018(1),2019(2),2020(3).I use year fixed effect. I use *,**, and *** to denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:		
	Interest Rate		
	(1)	(2)	(3)
Broadband Penetration	0.018*** (0.002)	-0.170*** (0.007)	-0.044*** (0.006)
Credit Score	-0.347*** (0.001)	-0.428*** (0.001)	-0.358*** (0.001)
Debt to Income	0.440*** (0.007)	0.590*** (0.007)	0.431*** (0.004)
Observations	480,795	640,551	1,289,822
R^2	0.133	0.137	0.114
Adjusted R^2	0.133	0.137	0.114
Note:			*p<0.1; **p<0.05; ***p<0.01