The Digital Divide and Refinancing Inequality

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Abstract

Low-income households derive significantly less savings from mortgage refinancing than their wealthy counterparts. I document that the rise of refinancing inequality in the United States can be partially explained by the gap in access to modern information and communications technology. Using granular spatial variation of a large-scale broadband subsidy program, I show that broadband internet facilitates refinancing activity and reduces monthly mortgage payments. These effects are large and persistent, corresponding to a 5 percent increase in disposable income and up to $13,000 in total savings for low-income households. The results are in large part driven by underbanked census tracts with low access to physical bank branches. Lastly, I show that households that are likely to have low digital literacy benefit the most from the program. I discuss the implications of these findings for financial inclusion and monetary policy transmission.

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1 Introduction

Mortgage refinancing is an important mechanism for household wealth accumulation in the United States. However, many Americans do not refinance their mortgages optimally due to frictions such as high origination costs or limited financial sophistication (Campbell, 2006). This phenomenon is concentrated among low-income and minority households, implying a potential imbalance in the transmission of monetary policy during economic downturns and increased wealth inequality. In this paper, I study whether at-home access to modern information and communications technology can help mitigate refinancing frictions. Specifically, I demonstrate that improved access to broadband services induces higher refinancing activity and reduced housing costs for low-income households.

High-speed internet can significantly reduce the shadow costs associated with applying for a refinance mortgage. Using the internet, an applicant can easily exchange paperwork by e-mail, link financial accounts online to expedite credit verification, and spend less time meeting with a loan officer or visiting a bank branch. Processing times for mortgage applications at online lenders are estimated to be 15 to 30 percent shorter than at their physical counterparts, with a larger effect for refinance loans (Fuster et al., 2019). Furthermore, to the extent that online resources help households obtain information about the value of refinancing, the internet can reduce the incidence of suboptimal refinancing driven by behavioral mistakes.

Despite the internet's large role in streamlining the refinance process, it is inaccessible to millions of American households living without a wired broadband connection at home. The persistent gap in access to information technology, known as the "digital divide," has become an important policy issue in recent decades due to its influence on household well-being (White House, 2022). In 2019, less than 70 percent of the population reported having a broadband subscription at home, with low-income households reporting significantly lower subscription rates (Figure 1). This trend is not entirely driven by imbalances in physical access to a broadband provider; of the households making less than $35,000 annually and living in urban areas with near-complete broadband coverage, only 65 percent subscribed to broadband during this period.

Using broadband access to study refinancing inequality is difficult for several reasons. First, broadband providers tend to operate in geographies with subscriber base characteristics that are correlated with refinancing demand, such as employment and educational attainment. Estimates of refinancing outcomes relating to heterogeneity in broadband access, therefore, will most likely be biased. Second, it difficult to observe exogenous changes in broadband adoption by households, especially low-income homeowners that tend to refinance suboptimally. As a result, little is known about the extent to which broadband access can reduce refinancing frictions.

To quantify the effect of broadband access on refinancing, I analyze the Internet Essentials program by Comcast, the largest broadband provider in the United States. Introduced in 2012, Internet Essentials heavily subsidized broadband subscription fees to qualifying low-income households. The monthly fee of $9.95 is up to 75 percent lower than a comparable regular plan, and all fees related to activation and equipment (averaging more than $100 upfront and up to $10 per month) were waived under this program. The program has been highly successful, connecting 750,000 American families (or 3 million individuals) nationwide in the first five years (Comcast Corporation, 2016). Internet Essentials is a suitable setting to study refinancing behavior due to its unique properties. First, it was immediately available in all of Comcast's existing service areas. This method of rollout is important because physical infrastructure expansions associated with other broadband initiatives not only take time but also can increase local house prices, confounding the estimated impact of broadband access on refinancing (Knutson, 2015). Second, the program was directly aimed at increasing take-up by low-income households making less than around $40,000 per year — the group that exhibits suboptimal refinancing behavior most prominently. Lastly, it coincides with the recovery period after the Great Recession when refinancing incentives and potential savings were high throughout the income distribution.

This paper exploits geographic, temporal, and household-level variation in Internet Essentials eligibility to analyze the impact of broadband access on refinancing demand and homeownership costs. Specifically, I compare outcomes of income-eligible and income-ineligible households across census tracts with high and low Comcast coverage rates before and after 2012. The identifying assumption is that within-tract differences in refinancing outcomes between eligible and ineligible households are uncorrelated with Comcast coverage rates except through the introduction of the Internet Essentials program. Indeed, I do not find any violation of the common trends assumption. I construct a unique data set that matches census tract-level Comcast coverage rates to the universe of refinance applications and originations by income eligibility criteria between 2008 and 2015. I also enhance my analysis using a matched panel data set of prepayment propensities for home purchase mortgages originated between 2004 and 2008, as well as American Community Survey microdata on mortgage payment burdens.

I find that improved broadband access leads to a strongly positive impact on refinancing outcomes. In particular, the number of refinance applications submitted and originated by eligible homeowners increased by 6 percent as a result of Internet Essentials. Interest rates and credit standards measured as denial rates were both unaffected. Loan- and household-level analyses corroborate these findings on increased refinancing propensity and decreased mortgage payment burdens. Moreover, I show that the results are in large part driven by census tracts with limited access to bank branches, implying that broadband promotes access to traditional banking services for the underbanked. I also find stronger effects for treated groups with low educational attainment, which suggests a digital literacy channel for refinancing.

The economic magnitudes of these results are significant: the average low-income household that refinanced its mortgage between 2012 and 2015 would have saved close to $100 per month on mortgage payments even after accounting for the nominal cost of subscribing to Internet Essentials. This translates to a 5 percent increase in monthly disposable income and total household wealth gains of up to $13,000 in present value terms, which is comparable with the average net worth of households in this income bracket. I estimate that the program generated up to $90 million in refinance savings for Comcast area households through 2015.

These empirical findings are robust to several validation and falsification tests. As Comcast's Internet Essentials is the only subsidy program during the study period, using treatment indicators for AT&T and Charter coverage instead (the next two largest broadband providers by subscriber count) should not yield any effects. Indeed, I find no effects of broadband access on refinancing outcomes under these placebo tests. I also verify that the effects are driven by census tracts with a high fraction of households with children at home and strong employment outcomes. Lastly, I confirm that the results disappear when I use households with incomes marginally above the eligibility threshold as the treated group, supporting the assumption that the program only affected eligible low-income households.

Related Literature (in progress). This paper is related to the growing literature on household finance and refinancing inequality. Campbell (2006) documents low levels of refinancing among low-income borrowers in the early 2000s. Agarwal et al. (2016, 2017, 2020); Defusco and Mondragon (2020); Fuster et al. (2021); Gerardi et al. (2020); Keys et al. (2016) all find evidence of suboptimal behavior driven by income and race during the aftermath of the Great Recession, and more recently, the COVID-19 pandemic. I provide additional causal evidence of refinancing frictions among creditworthy borrowers at the bottom end of the income distribution. The study period of 2012 and later also addresses possible confounders arising from the direct impact of the Great Recession and the recent pandemic.

Second, I contribute to the literature on broadband access in the modern economy. Akerman et al. (2015); Hjort and Poulsen (2019) study the effect of broadband introduction in Europe and Africa on employment outcomes. My paper is also closely related to Zuo (2021), which uses the Internet Essentials program to find a positive impact of broadband access on employment. To my best knowledge, prior works have not considered the impact of broadband access on household financial decisions. I provide the first evidence that broadband facilitates mortgage refinancing, which has significant implications for household wealth accummulation.

Third, this paper is related to recent works on the role of technology in mortgage lending. Fuster et al. (2019) documents the large role fintech lenders play in reducing processing times for mortgages. Importantly, the authors find no effect of broadband access on mortgage applications and originations, using the physical rollout of Google Fiber as an instrument. By studying a national program that did not require low-income customers to pay large upfront costs, I show that broadband internet can indeed help reduce frictions associated with refinancing.

Outline. The remainder of the paper is structured as follows. Section 2 describes the institutional background on broadband access and the Internet Essentials program. Section 3 describes the data and empirical methodology. Section 4 discusses the main results and studies the relevant mechanisms. Section 5 concludes.

2 Background

2.1 Mortgage Refinancing

Households use mortgages to purchase a new property or refinance an existing mortgage on a previously purchased property. Since most mortgages in the United States are fixed-rate loans without prepayment penalties, a refinance allows households to reduce their cost of credit when interest rates fall. In essense, the refinance decision is a call option that should be exercised when the original loan is "in the money" after adjusting for interest rate differentials and closing costs. Refinancing constitutes a large segment of residential real estate markets, accounting for more than half of all mortgage originations by volume between 2005 and 2015 (Mortgage Bankers Association).

Homeownership is one of the largest items on the balance sheet of American households, representing around 43% of total household wealth. Understanding the drivers of refinancing is important because it is one of the most consequential decisions a household makes. Homeownership costs are particularly significant for low-income households. are Around 46 percent of households with annual income less than $35,000 reside in owner-occupied units. This group of low-income households originated home purchase mortgages worth $780 billion between 2001 and 2008, with an average purchase price of $120,000 and monthly payments of $700 over 30 years. Housing cost burdens are also disproportionately large for this group, with more than half paying 30 percent or more of their monthly disposable income on housing. Reducing mortgage payments through refinancing, therefore, is an important way to increase household net worth.

Prior research has documented that many American households fail to refinance their mortgages when it is optimal to do so (Agarwal et al., 2016). These financial mistakes are particularly pronounced among low-income households; of the mortgages originated between 2004 and 2008 by households making less than $35,000 in annual income, only around 65 percent were refinanced at any point between 2009 and 2015, the period during which mortgage interest rates fell by an average of 2 percent. This stands in stark contrast to the refinancing propensity of loans originated by households making more than $75,000 (80 percent). The pronounced errors at the lower end of the income distribution persists even after controlling for home value.

2.2 Broadband Internet in the United States

Broadband technology, which grew in prevalence since the early 2000s, allows households to use the internet for all aspects of life such as work, education, and entertainment. In this paper, I define broadband as any residential, high-speed, wireline internet service available in a geographic area. I focus on residential (as opposed to commercial) service as it is relevant to at-home household financial decisions. High-speed status is determined by whether a service meets the standards for broadband set by the Federal Communications Commission (FCC). The minimum download speed for broadband was 4 megabits per second (Mbps) during the study period, which is adequate for general web browsing, e-mail communication, and some video streaming at low bandwidths.[1] Dial-up internet service, which typically has a maximum download speed of 56 kilobytes per second (Kbps), is considered inadequate for daily activities and thus outside the scope of this paper. Lastly, I only consider wireline service provided through physical broadband infrastructure. This is because wireless networks accessed through mobile devices were not reliable or advanced enough to replace broadband during the late 2000s and early 2010s.

[1]The 4 Mbps minimum speed standard for broadband was set in 2010 and then revised up to 25 Mbps in 2015.

The lack of broadband internet at home, particularly in urban areas, can largely be attributed to low affordability. Figure 2 shows a clear negative relationship between census tract poverty rates and broadband subscription rates. This trend is not driven by limited access to a broadband provider. In fact, more than 90 percent of the urban population in the United States lived in areas with broadband service by 2015, while only 70 percent (60 percent for low-income groups) reported actually having a broadband subscription.[2] Survey results from the Pew Research Center reveal that the price of subscription (59 percent) and cost of computer equipment (45 percent) are the top two reasons for not subscribing to broadband (Horrigan and Dugan, 2015). While the urban-rural disparity in broadband coverage is an important access-driven cause for the digital divide, I focus on cost-driven disparities in subscription conditional on having access. This distinction is useful for identification because it is invariant to unobservable differences in broadband service quality and customer demand across urban and rural areas.

2.3 Broadband and Refinancing Inequality

At-home internet access is relevant for refinancing inequality due to the unique properties of a refinance loan. First, refinancing is relatively standardized and compatible with technological innovation. In a refinance, the housing asset in question is already determined and the prospective borrower is in good standing on the existing mortgage.[3] Borrower uncertainty is thus low, allowing a large part of the refinance process to be streamlined and automated. Recent innovations in online approval and underwriting technology have led to a significant decrease in processing times for refinance applications.[4] The internet has also enabled both bank and non-bank lenders to reach populations outside their immediate geographic markets, improving the access to refinancing credit for underbanked households.

Second, refinancing involves high shadow costs for borrowers (i.e., time and cognitive effort) that can be drastically reduced through internet usage. A refinance typically takes several months to complete, largely due to stringent documentation requirements that include recent pay stubs, tax returns, W-2s, homeowners insurance policies, asset statements (e.g., checking, savings and investment) and debt statements (e.g., credit card and automobile). For the majority of American households that use online banking, these materials can be conveniently accessed and transmitted online with a computer

[2]Statistics are compiled from the 2015 FCC Broadband Progress Report and author's calculations using ACS 2013-2017 5-year estimates.

[3]Since a refinance requires current homeownership, it is not determined by exogenous motives to move into or out of a dwelling. This is important as it allows the borrower pool to be invariant from significant income shocks or migrational incentives.

[4]Fuster et al. (2018) find a 17 to 29 percent reduction in processing times for mortgage refinance applications submitted to fintech lenders, relative to an average of 51 days.

and broadband connection.[5] Furthermore, applicants with broadband can use e-mail to communicate with a loan officer and make fewer branch visits. To the extent that the internet can also increase households' awareness and provide resources to shop around for lenders and rates, broadband access at home has become an important way to reduce the shadow costs associated with refinancing.

Refinancing inequality persists in part because low-income households face large shadow costs that are exacerbated by their relative lack of broadband access. Figure 3 confirms the existence of a digital divide in refinancing: while refinancing propensity is lower throughout all income deciles in census tracts with limited broadband access, it is disproportionately lower for the bottom decile. As low-income households typically have thin credit files and irregular income streams, they may find it difficult to fulfill the verification and qualification requirements for a mortgage.[6] Moreover, these households tend to be underbanked and less confident in their ability to get approved for other types of credit, suggesting that refinancing demand may be low.[7] I argue that broadband access can meaningfully reduce these shadow costs by improving access to lenders, boosting borrower confidence, and disseminating information about the financial benefits of refinancing.

2.4 Internet Essentials Program by Comcast

Internet Essentials by Comcast provides a useful quasi-experimental setting to study the digital divide in mortgage refinancing. The program was originally conceived by Comcast to garner support for a proposed merger with NBC Universal, a large media and entertainment company. The merger was ultimately approved by the Federal Communications Commission (FCC), which enforced Comcast's commitment to institute the low-income subsidy program to promote public interest (FCC, 2011). In the beginning of 2012, Internet Essentials became available in all Comcast coverage areas nationwide and was the first comprehensive program of its kind by a major internet service provider.

Internet Essentials significantly reduces the cost of a broadband subscription. Enrolled households received high-speed broadband with 15 Mbps download and 2 Mbps upload speeds for a $9.95 monthly fee plus applicable taxes, which is about 30 percent lower than the average cost of a comparable unsubsidized broadband plan (Cost of Connectivity Report, 2013). Moreover, all one-time installation

[5] 55.1 percent of the population reported using online banking and one-third reported using it as the main method to access bank accounts (Federal Deposit Insuranec Corporation, 2013).

[6] Bhutta et al. (2018) find that only 51 percent of households in the bottom income quartile had at least $400 in savings for an unexpected expense, and 17 percent reported having savings worth 3 months of expenses.

[7] 27 percent of households with less than $40,000 in annual income were underbanked, compared to 11 percent for households with income above $100,000. 32 percent of low-income respondents reported not being confident in their ability to be approved for a credit card loan, compared to 7.2 percent for high-income respondents (Report on the Economic Well-Being of U.S. Households in 2015).

and activation fees ($100 or more) as well as modem and router rental fees (up to $20 per month) were waived. Fee savings over a three year period would have exceeded $1,720, which is a sizeable amount for eligible households with an average annual income of $30,000. Internet Essentials also offered subsidized computers for $149.99 and provided access to digital literacy training resources.

Eligibility requirements for Internet Essentials are carefully selected to maximize impact and convenience. A family qualifies if it has a child eligible for free or reduced-price lunch under the National School Lunch Program (NSLP). This guideline restricts eligibility to households with annual income below 185 percent of the federal poverty limit, which translates to around $35,000 (three-person family) or $42,000 (four-person family) between 2008 and 2015.[8] In addition to targeting outreach efforts in disadvantaged school districts, particularly in urban areas, Comcast further streamlined the application process by auto-approving households with children attending majority low-income schools. The program is also geared towards families that are less likely to have any existing broadband subscription, as an applicant must not have any past-due debt to Comcast and cannot have been a Comcast subscriber in the preceding 90 days.

Internet Essentials was highly successful, connecting more than 750,000 low-income families (or 3 million individuals) through 2016 (Comcast Corporation, 2016). Moreover, the program reached low-income households in urban areas more quickly due to the large emphasis on grassroots community partnerships.[9] Internet Essentials became an integral part of everyday life, with 89 percent of subscribers reporting using the internet almost every day. 92 percent used the internet to find general information and 80 percent used it for e-mail (Comcast Corporation, 2016). Importantly, 65 percent of subscribers said that banks or other financial institutions expect them to have internet access at home, and 42 percent used the internet to access banking and financial services (Horrigan, 2014; Horrigan, 2019).

3 Methods and Data Description

3.1 Empirical Design

I identify two challenges for quantifying the causal effect of Internet Essentials on refinancing. First, it is infeasible to directly compare outcomes for the same low-income group across Comcast and

[8]In 2010, 31.8 million children participated in the NSLP nationwide (United States Department of Agriculture, 2017).

[9]While the program was offered in 40 states, 75 percent of subscriptions came from the 10 populous states in the first five years. These states, in descending order by subscriber count, are: CA, FL, IL, GA, PA, TX, MI, WA, CO, and TN.

non-Comcast areas. Importantly, Comcast is fully operational in certain major cities (e.g., Chicago, Sacramento, Miami, Houston) and entirely absent in others (e.g., Los Angeles, New York, Dallas), making it difficult to identify two regions within a small geographic area with varying levels of Comcast coverage. A standard study of differences in refinancing behavior in Los Angeles and Sacramento (or Chicago and New York) is likely to suffer from unobservable confounders. Even after controlling for economic and financial indicators that affect a household's refinance decision (e.g., house prices and interest rates), I cannot rule out the impact of unobservable factors such as industry-by-tract employment outcomes, migration patterns, or nuanced changes in lending standards.

Second, comparing refinance outcomes of treated (low-income) and control (higher income) households in Comcast areas suffers from bias due to underlying trends between the two groups. As income is a primary predictor of mortgage principal, and by extension, monetary savings from refinancing, control households with marginally higher incomes are more likely to refinance in the early years following the Great Recession than treated households. Moreover, there is a natural attrition of the mortgage pool throughout the recovery period because refinancing is a typically one-time decision for most homeowners. This implies that any effects of program introduction in 2012 will suffer from a violation of the parallel trends assumption: control households will refinance earlier in the study period, resulting in a positive difference-in-difference coefficient that is biased by the higher trend of refinancing activity by treated households from 2012 to 2015.

I study Internet Essentials' impact on refinancing activity by using both levels of variation in geographic coverage and income eligibility, in conjunction with temporal variation pre- and post-program launch. In particlar, I use a triple differences design introduced by Gruber (1994) to compare the *gap* in refinancing outcomes between eligible and ineligible groups across Comcast and non-Comcast areas. Identification crucially relies on the assumption that the gap in outcomes between the two income groups will not vary with Comcast coverage before and after 2012 except through the impact of Internet Essentials. This is plausible because any confounders at the census tract level of geography will likely impact both eligible and ineligible groups concurrently.

Figure 4 illustrates the intuition behind the triple differences design. All three panels plot the average number of refinance originations made in a census tract, which is one of the main outcome variables of interest. Panel A shows that eligible groups in Comcast and non-Comcast census tracts follow divergent trends in refinancing behavior prior to the program's launch. Similarly, the ineligible and eligible groups in Comcast areas exhibits different trends before 2012 (Panel C). Lastly, Panel C verifies that the difference in refinancing behavior between eligible and ineligible groups in non

Comcast areas is consistent with the corresponding trend in Panel B.

3.2 Data Sources

Comcast Coverage Rates: I compute Comcast coverage rates using ISP service location data provided by the National Telecommunications and Information Administration (NTIA)'s State Broadband Initiative. The data reports whether an ISP provided any type of internet service in a given census block on a biannual basis. I restrict the provider responses to those that qualify for broadband service as defined in this paper, and aggregate the information up to the census tract level.

Mortgage Applications and Originations: The Home Mortgage Disclosure Act (HMDA) micro-data provides data on the near-universe of mortgage applications in the United States. Importantly, the data includes key demographic information such as income and geographic location or the property at the census tract level. For each year between 2008 and 2015, I count the number of refinance applications submitted by eligible and ineligible households in a given census tract. I also count the number of loans ultimately originated and compute denial rates by taking the ratio of denied mortgages to total applications.

Prepayment Activity: Prepayment involves the payment of a mortgage's principal before maturity. While there may be many reasons for prepayment including foreclosure, I focus on voluntary prepayment as a proxy for refinancing. I first measure voluntary prepayment of mortgages originated between 2004 and 2008 using loan performance files from Fannie Mae and Freddie Mac. In particular, I assign an indicator for whether a mortgage is prepaid between 2008 and 2011 (pre-Internet Essentials), and another indicator for whether a mortgage is prepaid between 2012 and 2015 (post-Internet Essentials). Performance data from the two government sponsored enterprises (GSEs) also contain the location of the loan as well as demographic and financial information, but do not have information on borrower income that is important for assigning treatment status. Thus, I programmatically merge the GSE filings to HMDA data using exact match categories (year of origination, agency, owner occupancy, loan type, number of applicants, and loan amount) and a fuzzy match category (location).[10] The resulting data set results in about 20 percent coverage of all mortgages originated and sold to the two GSEs. In addition to the demographic variables in the HMDA data, the matched data contains important loan-level covariates such as interest rate, debt-to-income ratio, loan-to-value ratio, and credit score.

[10] Further details on the matching process can be found in the Internet Appendix.

Interest Rates: Accurate loan-level interest rates at origination is only available in the GSE performance data, while HMDA has information on income that is important for treatment assignment. I use the same matching process detailed above to merge the two data sources, this time for refinance originations between 2008 and 2015.

Mortgage and Rental Costs: I obtain information on households' actual mortgage and rental costs from the Integrated Public Use Microdata Series (IPUMS) of the American Community Survey (ACS). The ACS publishes microdata on the cross-section of sample households each year. Importantly, the questionnaire has information about income and household composition that can help refine the assignment to Internet Essentials treatment. Mortgage and housing rental payments are directly included in the survey, as well as several useful covariates such as home value and demographic information (age, gender, race, educational attainment, etc.). The survey is administered on a subset of the population and geographic location is only made available at the PUMA level (average population above 100,000), which is much larger than a census tract (average population of 4,000).

Bank Branch Access: Branch-level location information is downloaded from the Federal Deposit Insurance Corporation (FDIC)'s Summary of Deposits. The data includes precise geographic coordinates for all FDIC-insured financial institutions each year. I compute the number of full service (Brick and Mortar or Retail) bank branches that are within a 2 mile radius of each census tract's population centroid as of 2010. Data on the center of population is obtained from the Census.[11]

House Prices: For specifications that do not rely on within-tract variation in house prices over time, I use the annual house price index (HPI) data published by the Federal Housing Finance Agency (FHFA). The data is available at the census tract level and capture the evolution of refinancing incentives for homeowners.

Fintech Lenders: Banks and financial institutions that allows a customer to complete the entire mortgage origination process online are classified as fintech lenders. I use the definition of fintech lenders suggested by Buchak et al. (2018) and Fuster et al. (2019). I then match these fintech classifications to the HMDA data based on the respondent's identity on each entry.

Other Demographics: The incidence of broadband inequality is crucially dependent on disparities in economic outcomes across urban and rural areas. To address this, I classify census tracts into urban

[11] I follow the 2 mile radius convention used by Covas (2019) to identify "banking deserts." Most of the urban census tracts in my sample are geographically small (about 7 square miles on average). Thus, it is not helpful to use the traditional measure that uses 10 miles as the concentration radius.

and rural areas using the scheme provided by the National Center for Health Statistics (NCHS).[12] In particular, I use the 2006 delineation of county-level urbanicity and match it to each census tract. Demographic characteristics such as tract-level unemployment, broadband usage, and educational attainment, are obtained from the ACS summary and microdata files.

3.3 Comcast Coverage Rates and Income Eligibility

The assignment to treatment in my empirical setting depends on two important sources of variation, Comcast coverage rates and income eligibility. To calculate Comcast coverage rates, I first restrict the NTIA's block-level coverage data to connection types that qualify as broadband according to the definition used in this paper. As census blocks are a clean subset of a census tract, I then aggregate the block-level data as of December 2011 (the year prior to Internet Essentials) by calculating:

$$Comcast_{c,2011} = \frac{\sum_{b=1}^{c} Population_{b,2010} \times \mathbf{1}(Comcast_{b,2011})}{Population_{b,2010}}, \tag{1}$$

where $Population_{b,2010}$ refers to the population of block b and $\mathbf{1}(Comcast_{b,2011})$ is an indicator for whether Comcast provides broadband service in block b in 2011. $Comcast_{c,2011}$ captures the fraction of tract c's population that has access to Comcast broadband.[13] To address the concern that Comcast coverage might change over time, I use the same method to calculate $Comcast_{c,2014}$ and take the average of the two rates to compute $Comcast_c$. Figure 5 presents the distribution of $Comcast_c$ in urban counties, which shows a clear bimodal distribution with peaks at 0 and 100 percent. This allows a clean identification of census tracts that have near-complete Comcast coverage.[14]

Eligibility for Internet Essentials also depends on whether a household meets income qualification requirements. These income thresholds are in turn determined by the size of the household and the existence of a school-aged child, which I cannot directly observe from the HMDA or GSE data. First, I assign eligibility based on the average size of a low-income household that subscribed to Internet Essentials (four-person). Specifically, I assume that a homeowner making less than 185 percent of the federal poverty limit for a three-person household will most likely qualify for Internet Essentials, while a homeowner making more than 185 percent of the limit for a five-person household will likely not qualify. This allows me to compute an intent-to-treat effect that is plausible as long as I can rule

[12] `https://www.cdc.gov/nchs/data_access/urban_rural.htm`

[13] As blocks and tracts cover a small footprint in urban metropolitan areas, it is plausible that the ability to connect a single household in a block (definition of coverage according to NTIA) corresponds to adequate service for all residents.

[14] For placebo tests, I use the same methodology to construct coverage rates for AT&T and Charter, the next two largest ISPs by subscriber count.

out the possibility of differential biases into and out of assignment across geographic areas. Next, I assume that all homeowners have a school-aged child between ages 6 and 18. Lastly, I restrict the control group to have income below 185 percent of the threshold for a six-person family. This allows me to focus on two groups with relatively similar income.

For analyses using ACS data, I can directly observe income, the existence and age of children, and family size for each household. I thus use a cleaner assignment to treatment that depends on the actual household size and whether there is a school-aged child. For income, I restrict treated families to those making less than 170 percent of the federal poverty limit to account for potential measurement error. I use two different control groups. One incorporates all ineligibles that either have incomes above 200 percent and below 270 percent of the respective federal poverty limit or do not have a school-aged child, or both, and the other only includes low-income ineligibles that have income below 170 percent of the federal poverty limit but do not have a school-aged child.

3.4 Final Sample

I restrict the final sample to census tracts in large central metropolitan counties as defined by the NCHS. This restriction is relevant because Internet Essentials' initial success was led by city government partnerships and school districts primarily in urban areas.[15] Limiting the analysis to urban areas guarantees the highest likelihood of broadband subscription by eligible low-income households after the program's launch.

Table 1 reports the top 15 high Comcast and non-Comcast metropolitan statistical areas (MSA) by population served. The large number of census tracts within each MSA and the relatively small geographic footprint helps rule out potential confounding effects across areas. I also map the locations of all census tracts in my sample in Figure 6 and show that Comcast coverage does not exhibit any patterns of regional clustering. Importantly, most of the non-Comcast areas (dark grey) coincide with permanent presence of AT&T or Charter (blue). This means that broadband environments across these two groups of tracts will be mostly similar; households will both have comparable levels of broadband quality and customer service, with the only difference being that eligible low-income households in Comcast tracts will save up to 75% on their subscription costs starting in 2012. I additionally drop census tracts that did not receive any refinance applications (regardless of income) in a given year between 2008 and 2015.

[15] In the first five years, 25 percent of Internet Essentials subscribers came from 10 cities and 75 percent came from 10 states (Comcast Corporation, 2016).

The final sample consists of 5,256 census tracts covering 57 MSAs. 2,430 tracts have higher than 50 percent Comcast coverage and 2,826 have less than 50 percent coverage.[16] Table 2 reports descriptive statistics for mortgages and households in high Comcast and no Comcast tracts by income eligibility status. Columns 2 and 3 (5 and 6) show that ineligible households have higher income and credit scores, purchase higher-valued homes, and receive more favorable interest rates than their eligible counterparts. Note that control households still have substantially lower income relative to the rest of the population (Columns 1 and 4). For the average low-income mortgage originated between 2004 and 2008, the interest rate differential for refinancing between 2008 and 2011 was between 1.2 and 1.3 percentage points, which exceeds the typical threshold for optimal refinancing cited in the literature (Agarwal et al., 2013). Average interest rates fell further by a percentage point between 2012 and 2015. High Comcast tracts also tend to have a larger fraction of black homeowners and smaller fraction of hispanic homeowners than low Comcast tracts. In general, the difference in observable mortgage-related outcomes between eligible and ineligible groups are consistent across regions, both for homes purchased before the Great Recession and for homes refinanced in the early recovery period of 2008 to 2011.

3.5 Effects of Internet Essentials on Refinancing

Mortgage Applications and Prepayment Activity. I first study changes in demand for and realized outcomes of refinance mortgages. The most direct measure for refinancing activity is the number of refinance applications submitted by households across eligibility groups by geographic area. Specifically, I estimate the following equation:

$$\begin{aligned} y_{i,c,t} = \alpha &+ \beta(Eligible_{i,c,t} \times Comcast_c \times Post_t) + X'_{i,c,t}\Phi \\ &+ \rho_1(\lambda_t \times \gamma_c) + \rho_2(Eligible_{i,c,t} \times \lambda_t) + \rho_3(Eligible_{i,c,t} \times \gamma_c) + \epsilon_{i,c,t}, \end{aligned} \tag{2}$$

where $y_{i,c,t}$ is the number of mortgage refinance applications submitted by households in income group i in census tract c in year t. I also replace the dependent variable with the number of refinance mortgages ultimately originated, and interest rates. $Eligible_{i,c,t}$ is a binary indicator for income group i's Internet Essentials program eligibility, $Comcast_c$ is a continuous measure of Comcast coverage rates in census tract c, and $Post_t$ indicates whether the year is after the introduction of Internet Essentials in 2012. $X'_{i,c,t}$ is a vector of eligibility group by census tract by year covariates, which include proxies for house price and income. Census tract-by-year fixed effects $(\lambda_t \times \gamma_c)$ absorb

[16] I use a continuous measure of Comcast coverage as the treatment indicator in all regression analyses. This is largely inconsequential because the distribution of coverage rates, as shown in Figure 5, is highly concentrated at 0 and 100 percent. All results are unchanged when I use an above 90 percent or below 10 percent coverage dummy as $Comcast_c$.

all census tract-specific trends that are invariant to Internet Essentials eligibility. Similarly, the interaction $Eligible_{i,c,t} \times \lambda_t$ controls for aggregate time-varying differences between eligible and ineligible groups. Lastly, $Eligible_{i,c,t} \times \gamma_c$ controls for permanent differences between eligible and ineligible groups in each census tract. For specifications that involve a count measure as the dependent variable, I use a Poisson pseudo maximum likelihood (PPML) regression to model the data (Santos et al., 2006; Correia et al., 2019). I also study the evolution of prepayment behavior for home purchase mortgages originated between 2004 and 2008 in a two-period model. I estimate the following equation:

$$\begin{aligned} prepay_{i,c,t} = \alpha + \beta(Eligible_{i,c,t} \times Comcast_c \times Post_t) + Y'_{i,c,t}\Phi \\ + \rho_1(\lambda_t \times \gamma_c) + \rho_2(Eligible_{i,c,t} \times \lambda_t) + \rho_3(Eligible_{i,c,t} \times \gamma_c) + \epsilon_{i,c,t}, \end{aligned} \tag{3}$$

where $prepay_{i,c,t}$ is a binary indicator for whether loan i in census tract c has prepaid by year $t \in \{2011, 2015\}$. $Eligible_{i,c,t}$ now indicates whether loan i qualifies for Internet Essentials at the time of origination, and I assume that eligibility status stays constant between origination and 2015. To address the concern that households with marginally higher income between 2004 and 2008 may have subsequently qualified for the program by 2012, I construct an additional control group with annual income between 185 percent and 370 percent of a seven-person household (\$55,000 to \$110,000). $Y'_{i,c,t}$ is now a vector of loan-specific covariates, which includes income, race, sex, number of applicants, interest rate at origination, loan-to-value ratio, debt-to-income ratio, credit score, loan amount, and mortgage tenure. Again, census tract-by-year fixed effects ($\lambda_t \times \gamma_c$) absorb all census tract-specific trends that are invariant to Internet Essentials eligibility and the interaction $Eligible_{i,c,t} \times \lambda_t$ controls for aggregate time-varying differences between eligible and ineligible groups. Similarly, $Eligible_{i,c,t} \times \gamma_c$ controls for permanent differences between income-eligible and income-ineligible groups in each census tract.

Housing Costs. An important testable prediction of refinancing is reduced mortgage payments. I use the ACS microdata to quantify Internet Essentials' effect on housing costs for both homeowners and renters. I estimate the following equation:

$$\begin{aligned} m_{i,p,t} = \alpha + \beta(Eligible_{i,p,t} \times Comcast_p \times Post_t) + Z'_{i,p,t}\Phi \\ + \rho_1(\lambda_t \times \gamma_p) + \rho_2(Eligible_{i,p,t} \times \lambda_t) + \rho_3(Eligible_{i,p,t} \times \gamma_p) + \epsilon_{i,p,t}, \end{aligned} \tag{4}$$

where $m_{i,p,t}$ is either the natural logarithm of monthly mortgage payments (rent payments) or the mortgage-to-income ratio (rent-to-income ratio) for household i in PUMA p in year t. $Eligible_{i,p,t}$, $Comcast_p$, and $Post_t$ follow the same definitions as in equation (2). $Z'_{i,p,t}$ is a vector of householdspecific covariates. The multi-way fixed effects absorb any variation that might threaten the validity of the identification strategy. Given that assignment to treatment (Comcast enrollment) might vary at geographic levels larger than the census tract (e.g. school districts and neighborhoods), I cluster standard errors at the PUMA level for all empirical specifications.

4 Results

4.1 Main Results

Refinancing Outcomes. I first estimate the causal effect of Internet Essentials on various mortgage outcomes (applications, originations, and interest rates) at the income group level. Column 1 in Table 3 presents triple differences estimates on mortgage applications. I find that the availability of Internet Essentials increased the relative number of new mortgage applications in a census tract by 6 percent, off a base of 20 applications in the full pre-treatment period. The number of ultimately originated mortgages also increases by 6 percent and both results are statistically significant at the 1 percent level.[17] Lastly, column 3 indicates that there were no improvements in refinance interest rates for treated households. This makes sense due to the relatively low creditworthiness of the study group.

Figure 7 plots time-varying triple difference estimates of the effect of Internet Essentials on mortgage refinancing outcomes. There are no treatment effects prior to the intervention period, and estimates on refinancing steadily grow over the first three years of the program's launch. The event study specification further supports the identifying assumptions behind a triple differences design.

I also supplement these results using prepayment outcomes for homes originally purchased between 2004 and 2008 and in good standing. The dependent variable of interest is whether a loan is voluntarily prepaid by 2011 and by 2015, with the assumption that prepayment proxies for refinancing given the loans' young tenure. Column 1 of Table 4 shows no effects on prepayment when comparing outcomes using the baseline income threshold of 2-3 person families (treated) and 5-6 person families (control). Column 2 expands the control group further to households with income above the 185 percent FPL threshold for 7 person families (around $55,000) and below twice that threshold. I find that Internet Essentials availability increases prepayment propensity by 2.1 percent (off a base of 62 percent), a result that is statistically significant at the 5 percent level. Using the richness in data under this specification, I further test for the role of refinance incentives in Column 3. Indeed, I find a stronger

[17] In unreported analysis, I do not find any effects of Internet Essentials on denial rates, which is consistent with the aforementioned findings on applications and originations.

effect on prepayment of 3.3 percent when I restrict the sample to mortgages with above-median credit scores. Together, these results confirm that refinancing outcomes improved as a result of Internet Essentials.

Next, I calculate the savings from refinancing for an eligible household living in a Comcast area. The average low-income homeowner that purchased a home between 2004 and 2008 had a mortgage principal of around $120,000 and an interest rate of 6.2 percent. Applying the prevailing interest rate between 2012 and 2015 of 4 percent, a household would have saved around $110 dollars per month by refinancing. These households still come out ahead by $100 even after accounting for the cost of Internet Essentials. $100 per month corresponds to about 5 percent of disposable income for this income bracket. More importantly, the present value of total savings for an average refinance loan is up to $28,800 per household or $13,000 after discounting over time and adjusting for closing costs.[18] These lifetime savings are 1.3 times the average net worth of this income group.

The aggregate economic impact of increased broadband is also substantial. A 6 percent increase in the number of refinance originations, off a base of 13,000 annual originations for the treated group prior to 2012, corresponds to 780 additional refinances per year (total origination volume of $100 million per year). Using the conservative measure of potential household wealth gains as a result of refinancing, I estimate an that Internet Essentials generated $44 million in aggregate savings between 2012 and 2015. Note that these results ignore the effect on non-urban households; as urban census tracts comprise about half of Comcast's coverage area, the upper bound of national savings due to Internet Essentials can be set at around $88 million.

Mortgage Payments. I further test whether Internet Essentials led to lower mortgage payments for treated households. This is an important empirical exercise given the incidence of suboptimal refinancing behavior, particularly among low-income households (Agarwal et al., 2016). Table 5 shows the results from estimating equation (4). Panel A uses a control group of all eligibles (higher income, no school-aged child, or both). I find that Internet Essentials decreased mortgage payments in treated areas by 3.2 percent and the mortgage-to-income ratio by 1.7 percent. The results are statistically significant at the 1 percent level and are robust to the inclusion of control variables for demographics (e.g., age, race, gender, educational attainment) and economic characteristics (income, home value). Additionally, Panel B improves on identification by comparing mortgage payment outcomes between low-income eligibles (with school-aged child) and low-income ineligibles (without school-aged child). This specification yields similar estimates for mortgage-to-income ratio and an

[18] Closing costs can often be waived for low-income borrowers through federal and state grant programs.

even larger effect on mortgage payments of 4.6 percent.

The average pre-treatment monthly mortgage payment for treated households is around \$700, which is consistent with the statistics from HMDA data. A 5 percent decrease in mortgage payment corresponds to \$35 in monthly savings or \$6,000 in adjusted present value terms. This serves as a lower bound for the treatment effect of Internet Essentials on mortgage payments because various closing costs are often rolled into the monthly payments. Since disposable income and discretionary savings for households making less than \$30,000 a year are extremely low, even \$35 a month could make a large difference in long-term financial health.

4.2 Mechanisms

In this section, I analyze the mechanisms through which expanding broadband access improves refinancing outcomes for low-income households. The unique empirical setting provides testable predictions for whether the internet helps households with low levels of access to traditional banking services and high barriers in obtaining financial information.

Better Access to Financial Services. I first study the program's impact on refinance originations after dividing my sample into three groups based on physical branch counts within 2 miles of the population center. In this analysis, I am comparing the gap in refinance outcomes between eligible and ineligible households across Comcast and no Comcast tracts with the same observed level of access to financial services.

Table 6 shows the results from estimating equation 2 for these subsamples separately. Indeed, I find that the effect of Internet Essentials is strongest in the bottom and top terciles of the distribution based on bank branch access. The coefficient for the low-access group is 7.2 percent and statistically significant at the 1% level, compared to the insignificant estimate of 4 percent for the group with medium branch access. These results imply that the program significantly benefited homeowners who would have had to spend more effort seeking a refinance, and that access to traditional banking services explains at least some of the inequality in refinancing behavior. This is further supported by the null effect on the full sample for the share of fintech (online) lender refinance originations, implying that households did not completely substitute into using the internet for pursuing a refinance. Lastly, tracts with highest levels of branch access exhibit a 9.7 percent growth in refinancing activity due to the program. In these highly dense urban clusters, it is plausible that branch access also correlates with high employment and awareness through social networks.

Digital Literacy. Table 7 tests whether the effect of Internet Essentials is driven by improvements in digital literacy for low-income households. Indeed, column 1 shows that the effect of the program is largest (8.8 percent) when comparing the gap in refinance originations across treated and control tracts at the bottom tercile of population with at least a high school degree. These results support the hypothesis that the program did not simply benefit areas with ex-ante higher levels of digital and financial literacy. It is also plausible that the free training programs offered by Comcast had a large positive effect on households' financial decisionmaking.

4.3 Robustness Tests

Placebo ISPs. Internet Essentials was the only broadband subsidy program of its kind in the early 2010s.[19] This means that my causal estimates on refinancing should disappear when I assign AT&T or Charter as the entity that provided the Internet Essentials program in 2012. Specifically, I compute coverage rates $AT\&T_c$ and $Charter_c$ at the census tract level and estimate equation 2. Table 8 reports the results. Indeed, I find no effect of a placebo broadband program instituted in high AT&T and high Charter areas. These coefficients provide further support for the validity of my results that a substantial monetary intervention can have large effects on refinance decisions.

Alternative Eligibility Cutoffs. Eligibility is importantly based on household income and family composition, the latter of which I cannot directly measure in my data. The use of income group proxies may thus be contaminated by biases that drive the results. In column 2 of Table 9, I show that assigning a placebo treated group at the 5-6 person threshold and control group at the 7-8 person threshold does not yield any statistically significant effects on mortgage refinancing. The disappearance of an effect at higher levels of income in which Internet Essentials would have played no role verifies the targeted nature of the program and rules out the possibility that income-based differences in trends alone led to my findings.

Probability of Eligibility. In addition to testing alternative cutoffs, I consider whether the effects are driven by census tracts that are more likely to have a large pool of new program subscribers. In the top panel of Table 10, I show that census tracts with a higher fraction of families with a child between ages 6 and 18 at home drive the empirical results of Internet Essentials on refinancing behavior. Moreover, to the extent that ex-ante employment outcomes are likely correlated with refinancing behavior in the aftermath of the Great Recession, the bottom panel shows that the estimates are only significant in census tracts with low unemployment rates between 2007 and 2011,

[19] Other top ISPs introduced similar initiatives starting in 2016, and more programs were provided through federal and state governments throughout the COVID-19 pandemic.

a proxy for strong economic resilience.

5 Conclusion

Failing to refinance a mortgage when it becomes profitable to do so leads to large welfare losses. This phenomenon is particularly prominent among low-income and minority households, exacerbating the growing wealth inequality in recent decades. I study whether persistent disparities in access to modern information and communications technology explains suboptimal refinancing behavior by exploiting a large-scale natural experiment that brought broadband to more than low-income 750,000 households between 2012 and 2015. Using an identification strategy that accounts for geographic, temporal, and household-level variation in program availability, I find a strong and positive effect on refinancing outcomes that lead to a decrease in mortgage cost burdens. The economic significance of the results are large and persistent, resulting in total payment savings that well exceed the average net worth of low-income households in the study. The effects are driven by areas that are underbanked and with low levels of educational attainment. and I conduct various robustness and falsification tests to confirm that my findings are indeed driven by increased access to broad band internet.

My results have important implications for monetary policy, mortgage contract design, and infrastructure policy. First, the pass-through of accommodative monetary policy via refinancing may be hindered by non-cost frictions that different households face. To the extent that the digital divide and the resulting incidence of low convenience and awareness can contribute to suboptimal refinancing, policy makers should consider the welfare implications of focusing on conventional monetary policy during economic downturns. Moreover, financial institutions may develop and market products that flexibly address the low exercise levels of in-the-money refinancing options by low-income homeowners. Lastly, federal and local governments should continue their efforts to get Americans connected to broadband both through improvements in affordability and physical access.

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6 Figures and Tables

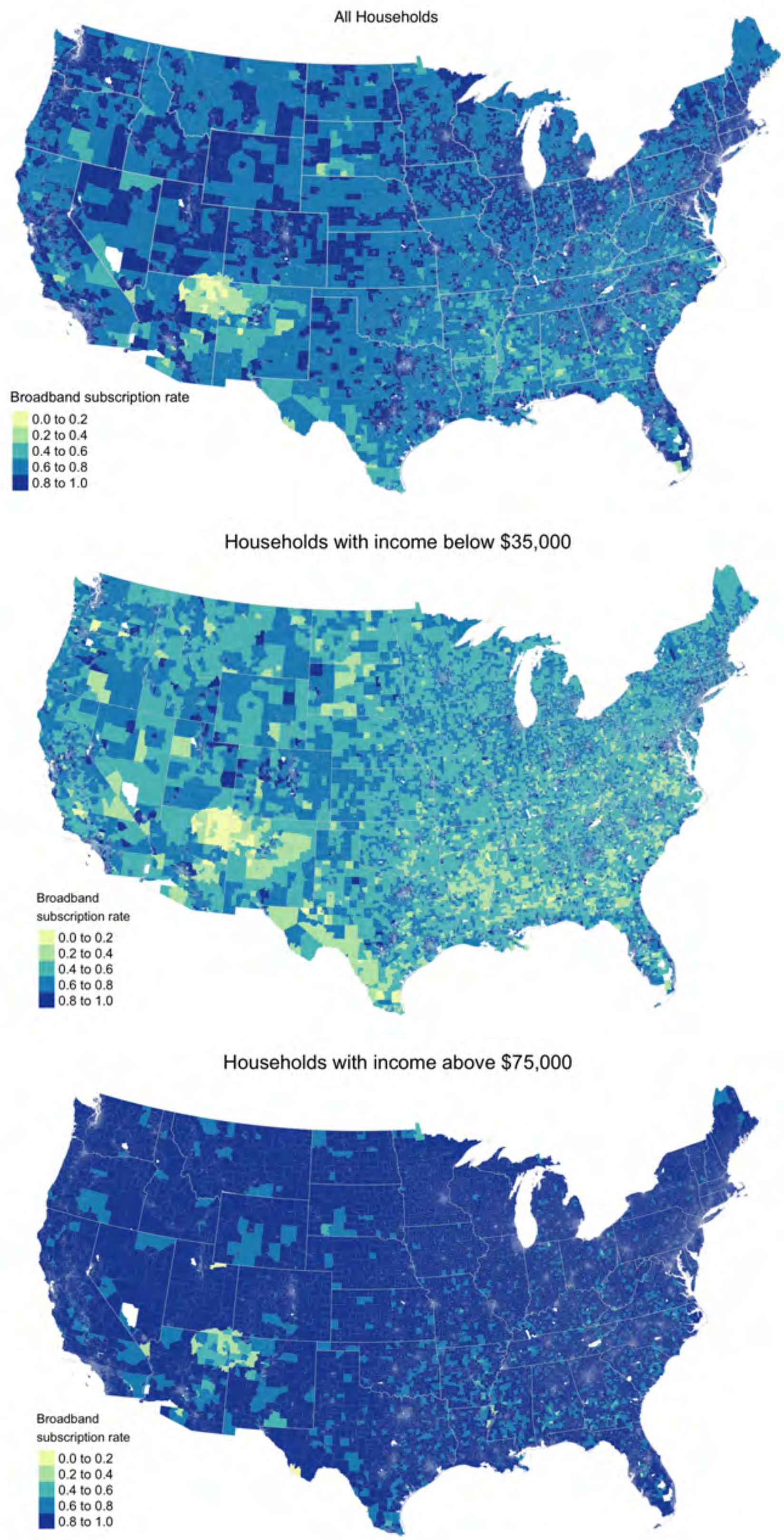

Figure 1: **Broadband Affordability and the Digital Divide (2019)**

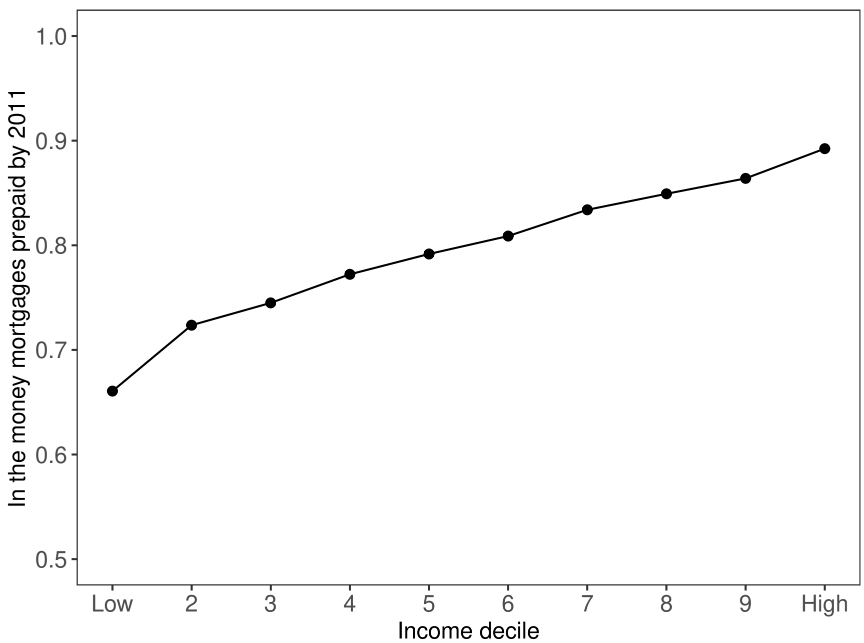

Figure 2: **Household Income and Refinancing Inequality**

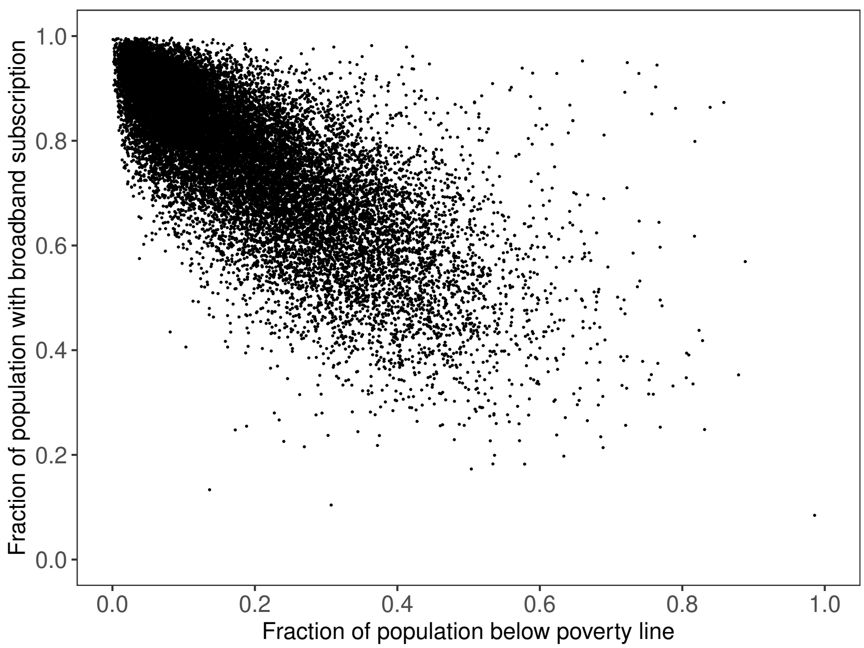

Figure 3: **Poverty and Broadband Subscription Rates**

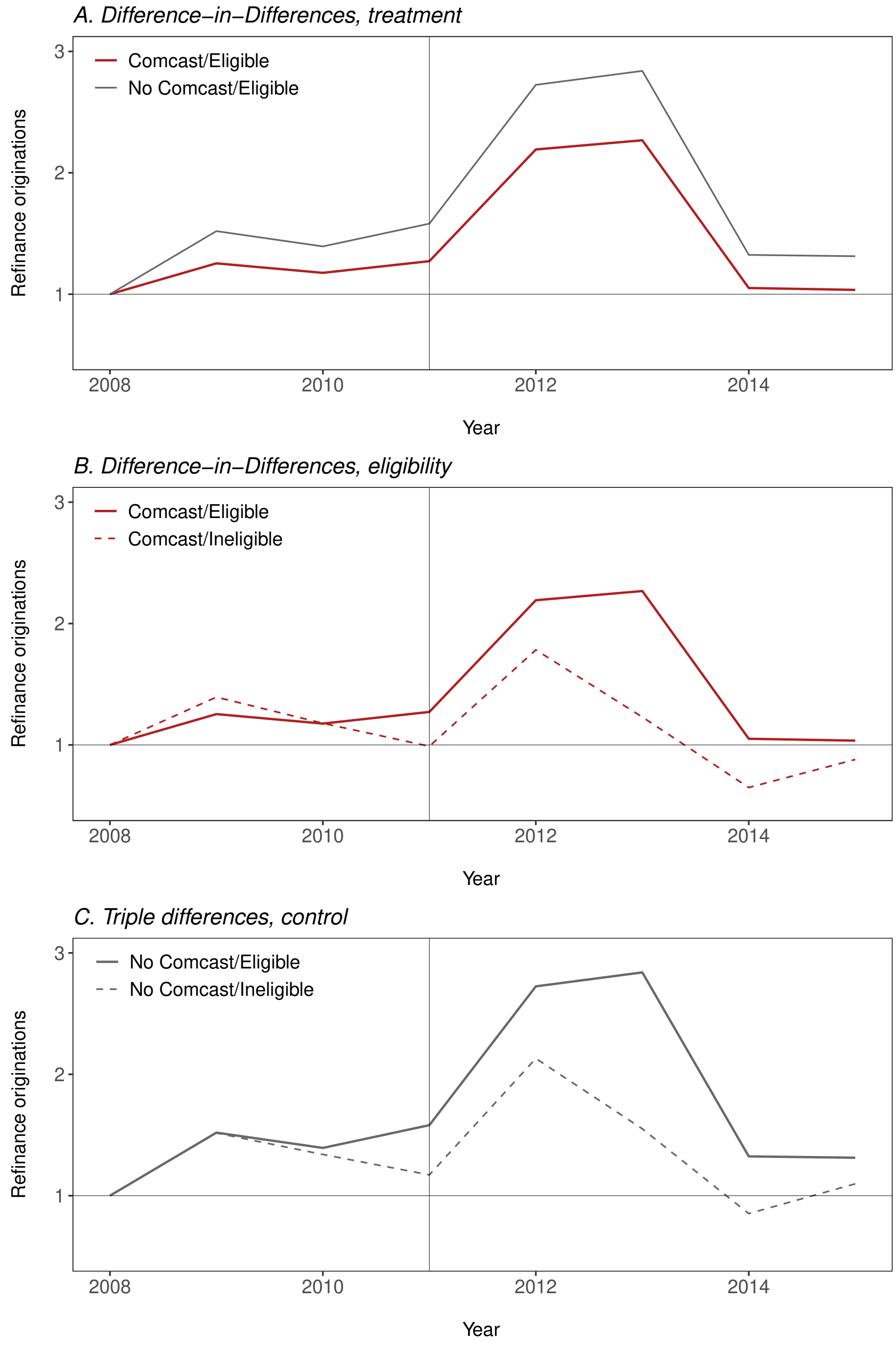

Figure 4: **Unconditional Trends in Refinancing Activity**

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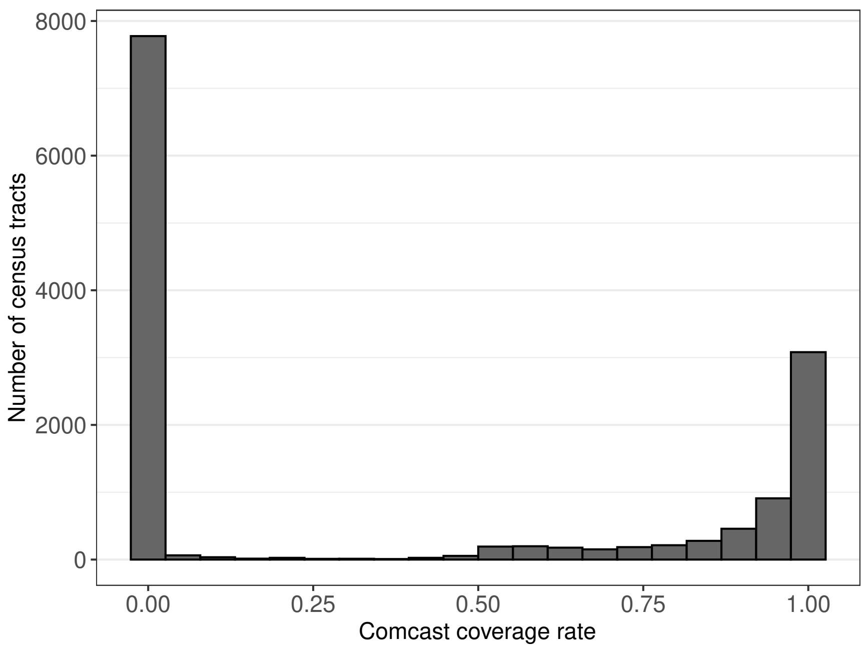

Figure 5: **Distribution of Comcast Coverage Rates**

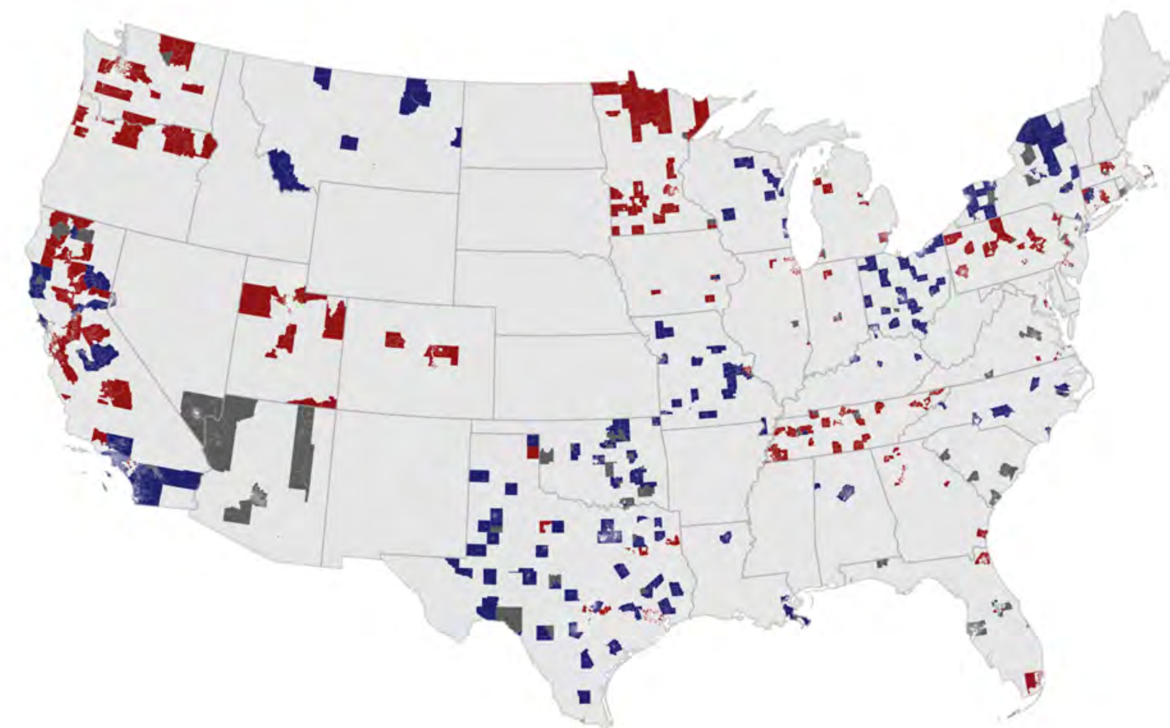

Figure 6: **Urban Census Tracts and Comcast Coverage**

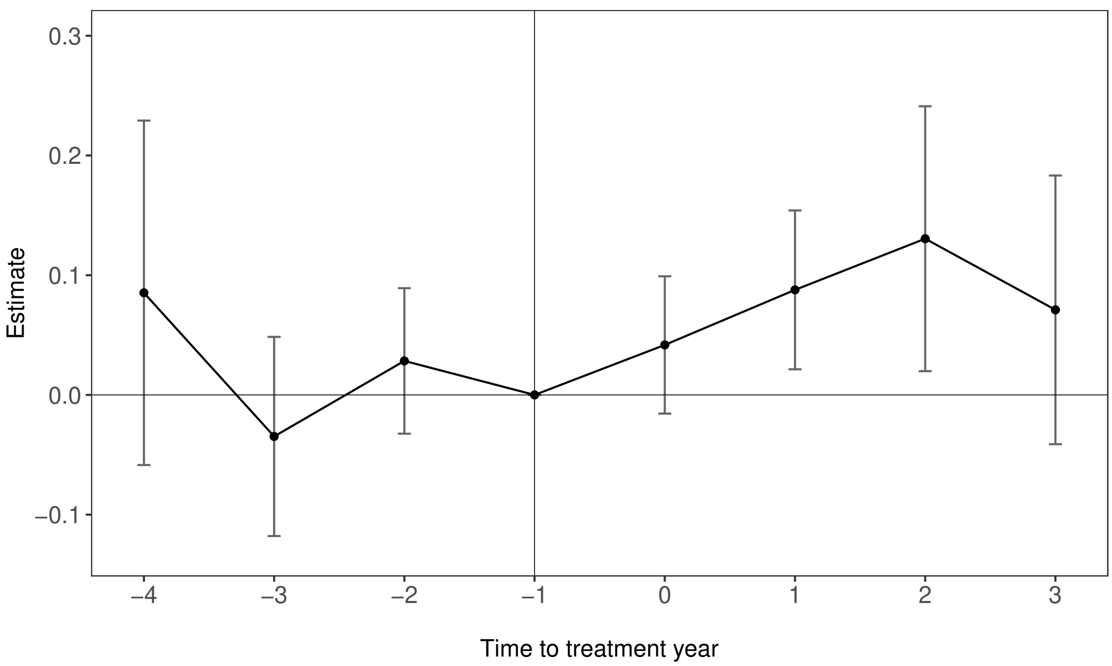

Figure 7: **Time-varying Estimates of Mortgage Refinancing**

Table 1: **Urban Metropolitan Statistical Areas by Comcast Coverage**

		Tracts	2010 Pop. (millions)
High Comcast			
1	CHICAGO-NAPERVILLE-JOLIET, IL	184	1.935
2	MINNEAPOLIS-ST. PAUL-BLOOMINGTON, MN-WI	237	1.446
3	SAN JOSE-SUNNYVALE-SANTA CLARA, CA	113	1.340
4	OAKLAND-FREMONT-HAYWARD, CA	231	1.312
5	SACRAMENTO–ARDEN-ARCADE–ROSEVILLE, CA	111	1.193
6	MIAMI-MIAMI BEACH-KENDALL, FL	91	1.182
7	HOUSTON-SUGAR LAND-BAYTOWN, TX	94	0.994
8	PHILADELPHIA, PA	55	0.941
9	SEATTLE-BELLEVUE-EVERETT, WA	166	0.927
10	PITTSBURGH, PA	227	0.918
11	SALT LAKE CITY, UT	82	0.850
12	SAN FRANCISCO-SAN MATEO-REDWOOD CITY, CA	129	0.730
13	PORTLAND-VANCOUVER-BEAVERTON, OR-WA	93	0.678
14	WASHINGTON-ARLINGTON-ALEXANDRIA, DC-VA-MD-WV	100	0.658
15	DETROIT-LIVONIA-DEARBORN, MI	165	0.653
No Comcast			
1	LOS ANGELES-LONG BEACH-GLENDALE, CA	1233	9.200
2	NEW YORK-WHITE PLAINS-WAYNE, NY-NJ	939	4.154
3	SANTA ANA-ANAHEIM-IRVINE, CA	144	3.007
4	SAN DIEGO-CARLSBAD-SAN MARCOS, CA	216	2.926
5	PHOENIX-MESA-SCOTTSDALE, AZ	178	2.041
6	DALLAS-PLANO-IRVING, TX	160	1.976
7	TAMPA-ST. PETERSBURG-CLEARWATER, FL	144	1.556
8	FORT WORTH-ARLINGTON, TX	87	1.507
9	RIVERSIDE-SAN BERNARDINO-ONTARIO, CA	83	1.371
10	LAS VEGAS-PARADISE, NV	61	1.170
11	SAN ANTONIO, TX	94	1.127
12	COLUMBUS, OH	139	0.980
13	CLEVELAND-ELYRIA-MENTOR, OH	143	0.933
14	AUSTIN-ROUND ROCK, TX	39	0.875
15	CINCINNATI-MIDDLETOWN, OH-KY-IN	127	0.731

Table 2: **Descriptive Statistics**

	High Comcast			Low Comcast		
	All	Low-income eligible	Low-income ineligible	All	Low-income eligible	Low-income ineligible
	(1)	(2)	(3)	(4)	(5)	(6)
Household income						
'04-'08 purchase	98.75	24.00	45.71	113.41	23.90	45.65
'08-'11 refinance	99.94	24.77	50.21	104.21	24.81	50.21
Loan count						
'04-'08 purchase	646.16	30.15	49.34	661.30	38.49	51.84
'08-'11 refinance	389.01	20.09	21.51	324.44	21.55	21.17
Loan amount						
'04-'08 purchase	233.50	114.08	135.74	291.05	117.84	139.00
'08-'11 refinance	203.13	122.83	148.46	245.20	136.01	166.76
Interest rate (pct.)						
'04-'08 purchase	5.98	6.20	6.07	6.02	6.18	6.10
'08-'11 refinance	4.83	4.92	4.94	4.83	4.90	4.91
Debt-to-income						
'04-'08 purchase	36.76	36.11	37.35	36.57	36.12	36.95
'08-'11 refinance	31.91	32.05	32.71	32.06	32.63	32.74
Loan-to-value						
'04-'08 purchase	80.03	78.17	80.97	79.45	78.61	80.69
'08-'11 refinance	65.79	60.33	65.15	65.58	60.53	65.02
Credit score						
'04-'08 purchase	739.25	726.89	734.63	737.07	726.49	732.40
'08-'11 refinance	763.86	757.19	758.65	760.89	757.24	757.40
Male (pct.)						
'04-'08 purchase	61.74	46.00	53.74	63.54	47.88	56.12
'08-'11 refinance	64.04	41.06	53.13	64.68	43.60	55.47
Black (pct.)						
'04-'08 purchase	11.39	22.40	17.09	7.31	15.97	11.09
'08-'11 refinance	6.28	17.74	11.60	5.12	11.29	7.92
Hispanic (pct.)						
'04-'08 purchase	14.47	18.62	17.04	17.51	21.00	18.66
'08-'11 refinance	6.27	12.51	10.24	11.07	19.91	16.56

Table 3: **Effect of Internet Essentials on Refinancing Demand**

	Applications (1)	Originations (2)	Interest Rate (3)
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$	0.060***	0.060***	0.003
	(0.020)	(0.025)	(0.016)
Observations	82,768	81,782	119,739
Adjusted R^2	0.724	0.642	0.859
Controls	Group	Group	Loan
Fixed Effects	✓	✓	✓

Table 4: **Effect of Internet Essentials on Mortgage Prepayment**

		Higher income control group	
	Baseline (1)	All (2)	Good credit (3)
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$	-0.003	0.021**	0.033***
	(0.014)	(0.011)	(0.014)
Household Size Groups	2-3 vs. 5-6	2-3 vs. 7-10	2-3 vs. 7-10
Observations	94,948	459,156	220,898
Adjusted R^2	0.238	0.233	0.212
Controls	Loan	Loan	Loan
Fixed Effects	✓	✓	✓

Table 5: **Effect of Internet Essentials on Housing Costs**

	log(Mortgage payment)	Mortgage-to-income
	(1)	(2)
$(Eligible_{i,p,t}) \times (Comcast_p) \times (Post_t)$	-0.032***	-0.017***
	(0.013)	(0.005)
Observations	214,933	214,933
Adjusted R^2	0.479	0.550
Controls	✓	✓
Fixed Effects	✓	✓
$(LI\ Eligible_{i,p,t}) \times (Comcast_p) \times (Post_t)$	-0.046***	-0.016***
	(0.018)	(0.006)
Observations	97,714	97,714
Adjusted R^2	0.473	0.498
Controls	✓	✓
Fixed Effects	✓	✓

Table 6: **Effects via Improved Access to Banking Services**

Dependent variable: Originations	Bank Branch Access Bottom (1)	Middle (2)	Top (3)	% Fintech (4)
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$	0.079***	0.050***	0.024	0.002
	(0.026)	(0.023)	(0.049)	(0.006)
Avg. # bank branches < 2 mi	4.75	15.13	48.84	
Observations	27,648	47,424	7,696	82,768
Adjusted R^2	0.753	0.706	0.519	0.184
Controls	Group	Group	Group	Group
Fixed effects	✓	✓	✓	✓

Table 7: **Internet Essentials and Financial Literacy**

Dependent variable: Originations	% Min. High School Degree Bottom (1)	Middle (2)	Top (3)
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$	0.125***	0.044	0.059***
	(0.053)	(0.032)	(0.028)
High school degree or higher	0.72	0.90	0.97
Observations	19,958	34,550	27,274
Adjusted R^2	0.557	0.653	0.662
Controls	Group	Group	Group
Fixed effects	✓	✓	✓

Table 8: **Placebo Tests using Other Large ISPs**

Dependent variable: Originations	(1)	(2)
$(Eligible_{i,c,t}) \times (AT\&T_c) \times (Post_t)$	-0.009	
	(0.023)	
$(Eligible_{i,c,t}) \times (Charter_c) \times (Post_t)$		-0.009
		(0.045)
Observations	81,782	81,782
Adjusted R^2	0.642	0.642
Controls	Group	Group
Fixed effects	✓	✓

Table 9: **Placebo Eligibility Cutoffs**

Dependent variable: Originations	Baseline (1)	Placebo (2)
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$	0.060***	
	(0.025)	
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$		0.003
		(0.011)
Household size groups	2-3 vs. 5-6	5-6 vs. 7-8
Observations	81,782	76,972
Adjusted R^2	0.642	0.642
Controls	Group	Group
Fixed effects	✓	✓

Table 10: **Falsification Tests for Probability of Program Impact**

	% Children at home		
	Bottom	Middle	Top
Dependent variable: Originations	(1)	(2)	(3)
$(Eligible_{i,c,t}) \times (Comcast_c) \times (Post_t)$	0.007	0.078***	0.076***
	(0.040)	(0.030)	(0.033)
Mean	0.20	0.31	0.45
Observations	21,244	33,340	27,198
Adjusted R^2	0.586	0.636	0.673
Controls	Group	Group	Group
Fixed effects	✓	✓	✓