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Understanding uptake in demand-side broadband subsidy programs: The affordable connectivity program case

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ABSTRACT

The Affordable Connectivity Program (ACP) represents a historic investment by the federal government to address the digital divide. Its goals are both to increase the rate of broadband adoption and make it easier for low-income households to sustain service. But what have been the drivers of ACP enrollment? We know a great deal about trends in adoption and the geography of enrollment among eligible households. But those metrics – especially a focus on enrollment rates among eligible households – are only so useful in explaining ACP sign-ups.

This invites analysis that investigates the drivers of ACP enrollment in a comprehensive way, which this paper proposes to do. The paper hypothesizes that ACP enrollment decisions are not solely individual (i.e., that a household's enrollment decision is structured only by income level), but also influenced by community-wide considerations, such as housing costs, share of occupied houses, presence of anchor institutions such as public libraries, and population density (i.e., whether a place is urban or rural). The paper develops a regression model that predicts ACP enrollment rates among eligible households at the 5-digit zip code geography as a function of the variables discussed above, as well as others such as the racial and ethnic make-up of a zip code area. The analysis also controls for existing levels of broadband subscriptions and computer ownership in a given area. The difference between predicted and actual ACP enrollment rates at the 5-digit zip code level is proposed as a metric of ACP performance. These findings are supplemented with a geographically weighted regression (GWR) model that allows the relationship between each explanatory variable and ACP enrollment to vary by locality. This allows for analyzing and visualizing how these relationships vary across space.

The empirical findings show that high levels of economic distress are a strong determinant of ACP enrollment in a given area, but social and community-wide indicators are important as well. The GWR results demonstrate that important differences in these relationships exist across geographies. Understanding spatial variations in ACP performance can help policymakers and other stakeholders better target resources to address the digital divide.

1. Introduction

Broadband access is broadly recognized today as a household necessity, similar to electricity and telephony in the 20th century

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(Sawhney & Ekbia, 2022). However, until the onset of the COVID-19 pandemic, the United States had a single federal program (called Lifeline) that offered only a small connectivity subsidy for low-income households. Further, and despite mixed evidence (Horrigan, 2022), the Lifeline program had a reputation for abuse and poor targeting (Ford, 2019, 2020). As a result, political support for direct subsidies for broadband service to vulnerable households was generally weak.

The onset of the pandemic changed the terms of the debate about universal broadband access, and in particular about the need to provide direct subsidies to households that could not afford service at market rates. Helping vulnerable households get and stay connected became a policy priority at a time when the internet was often the only way to access essential services. The launch of the Emergency Broadband Benefit (EBB) program in mid-2021, later replaced by the Affordable Connectivity Program (ACP) in 2022, thus represented a major shift in universal service policy in the United States.

As a means-tested program, ACP required that households actively apply and demonstrate eligibility to receive benefits. The statute enumerates the ACP eligibility criteria, which includes households whose annual income is at or below 200% of the federal poverty level (FPL) or that participate in certain social benefit programs. After a slow start, estimates suggest that the ACP participation rate among eligible households had reached about 43% in late 2023 (ILSR, 2023). This means that two years after the program launched less than half of the potential recipients were enrolled in ACP.

The relatively low level of participation in ACP, a program that in many cases lowered the cost of residential broadband to zero, invites exploration about the drivers of uptake in direct subsidy program for broadband connectivity, including both demographic and spatial variations in participation levels. From this perspective, ACP is no different from other means-tested government programs, with enrollment subject to a variety of forces that include program awareness, ease of enrollment, and the stigma attached to participation (Ko & Moffitt, 2022). This study draws on the broader literature about uptake in social safety net programs to empirically examine the drivers of participation in ACP.

Further, this study examines ACP uptake through the lens of technology adoption, drawing in particular from previous work that examines how social factors and local externalities affect adoption. Scholars have long evaluated the adoption of new communication technologies in the broader social context, from telephony in the early 20th century (Fischer, 1992, pp. 66–67) to email and personal computers in the 1990s (Goolsbee & Klenow, 2002; Sproull, 2000) to broadband in the 2000s (Rainie & Wellman, 2012). Broadly speaking, these studies recognize that, beyond individual preferences and barriers (including affordability), personal networks, the strength of social cohesion, and the presence of anchor community organizations also play an important role.

This paper is an empirical exploration of the drivers of ACP uptake that considers both the individual and the social dimensions of participation, and uses the geography of enrollment as a way to capture both elements. The paper leverages the availability of ACP enrollment data at the 5-digit zip code level and combines it with information from the American Community Survey (ACS), specifically with 5-year estimates that include data for 5-digit zip codes. The ACS information captures demographic and economic characteristics, technology adoption among households, and other characteristics that are known to affect broadband adoption, such as the presence of children in the household, the degree of “rent burden” among households, the share of foreign-born residents, and several others. By hypothesizing that ACP enrollment decisions are not solely driven by individual household characteristics, this paper looks beyond eligibility criteria and probes for social factors that affect participation in direct subsidy programs for broadband.

The evidence presented builds from a regression model that predicts ACP enrollment at the 5-digit zip code level as a function of demographic variables as well as variables that capture the broader social context, including the presence of a local library and the number of local broadband providers that might be advertising the program. The dataset includes information for approximately 25,000 U.S. zip codes. In addition to the traditional regression approach, the paper also implements a geographically weighted regression (GWR) that seeks to capture local variations in how each of these individual and local context factors affects ACP uptake.

At the time of writing, ACP is slated to end when its funding expires in May 2024 (FCC, 2024a, pp. 21–450). To a certain extent, the program was seen as a pandemic-era initiative whose need diminished as the pandemic subsided. Although there have been bipartisan expressions of support for ACP, there has not, to date, been a funding vehicle for appropriating additional funds. Explicit opposition to renewing the program centered on the idea that ACP is not enrolling enough new subscribers, that is, households who had not been home internet subscribers prior to signing up for the benefit (Bode, 2024).

Notwithstanding ACP’s demise, understanding the drivers to enrollment is relevant as policymakers consider changes to the Lifeline program or future subsidy programs for broadband service. The study results can thus inform policymakers and other stakeholders in several ways. First, the results enable a comparison of *predicted* ACP enrollment in an area to *actual* enrollment. This difference serves as a benchmark indicator to assess where ACP enrollment levels may be lagging - in other words, it helps identify the characteristics of areas of underperformance as well as those of over-performance. As such, the latter may also provide best-practice cases for locations with lagging enrollment in connectivity subsidy programs. Further, the results advance our understanding of the demographic and local area factors that determine enrollment in broadband support programs. Finally, results from the GWR model allow for examining which drivers of program uptake are more relevant in different geographic locations – which in turn offers opportunities for case studies of ACP enrollment success. These findings advance our understanding of the relation between local context, individual household characteristics and participation in means-tested benefits programs.

The paper is organized as follows: the next section (section 2) describes the origins and objectives of the ACP. This section is followed by a summary of the literature on the factors that determine uptake of social benefits programs (section 3) as well as of the literature on the social dimension of technology adoption (section 4). Model results are presented in section 5, followed by conclusions and policy implications in section 6.

2. Origins of the ACP

The ACP started life as the Emergency Broadband Benefit (EBB), a \$50 per month service subsidy created by the Consolidated Appropriations Act of 2021. The \$3.2 billion EBB program was focused on helping people get online and assisting those who lost service due to economic hardship brought about by the pandemic. The Infrastructure Investment and Jobs Act (IIJA) in late 2021 transitioned EBB to ACP in the form of a \$14.2 billion fund to provide a \$30 per month service subsidy and a \$100 device subsidy. By statute, the ACP provides a higher monthly subsidy (\$75) for households located in qualifying tribal lands. Notably, these households do not have to be tribal to take advantage of the higher subsidy. The increased subsidy of up to \$75 per month was later expanded to households living in qualifying high-cost areas (FCC, 2023a).

The eligibility criteria for ACP involved a combination of a household income threshold and participation in qualifying social programs. A household was eligible for ACP if its annual income is at or below 200% of the FPL, or if any household member.

- Participates in Supplemental Nutrition Assistance Program (SNAP), Medicaid, Federal Public Housing Assistance, Supplemental Security Income (SSI), Women, Infants, and Children (WIC), or Lifeline.
- Participates in Tribal specific programs, such as Bureau of Indian Affairs General Assistance, Tribal Temporary Assistance for Needy Families (TANF), or Food Distribution Program on Indian Reservations.
- Is eligible to participate in the National School Lunch Program or the School Breakfast Program.
- Received a Federal Pell Grant during the current award year.
- Meets the eligibility criteria for a participating broadband provider's existing low-income internet program, which generally involves a combination of the above criteria.

The objectives of the ACP were twofold. The first was to help households who have not had service get online, and the second was to ease the financial burden of having service for households that struggle with affordability. Implicit in these objectives is the recognition, notwithstanding the binary nature of the term "digital divide," that many low-income households are better characterized as being *broadband vulnerable*, traversing both sides of the digital divide at different points in time (Gonzales, 2016). Affordability challenges were exacerbated during the pandemic. One report found that 18% of lower-income households lost service due to difficulty paying for service (Horrigan, 2021a). In Philadelphia, this problem was acute for households living near the poverty line, with 31% of households with incomes under \$20,000 annually saying they lost service during the pandemic due to economic difficulties (Horrigan, 2021b). In California, nearly one in five low-income residents with connections reported having gone without Internet service at home for a period of time during the pandemic (CETF, 2021).

The term that captures the set of lower-income connected households who have affordability problems that place them on the precipice of disconnection is *subscription vulnerability*. These are households whose annual incomes are \$50,000 or less and say they suffered disconnection during the pandemic, searched for a cheaper plan, or said they find it difficult to afford service. This comes to half (49%) of lower-income households (Horrigan, 2021a). There are, of course, those who are not online who have never had a home internet subscription. This does not mean that these individuals do not go online at all – some of these people may be internet users that rely only on a mobile phone to go online or use connectivity at a coffee shop or local public library. Survey data from 2021 suggest that about two-thirds of those who did not have a home wireline broadband subscription at that time had not previously subscribed to the service (Horrigan, 2021a).

This analysis suggests that, at any given time, the digital divide can be conceptualized as comprising three distinct groups.

1. *The subscription vulnerable*: low-income households who are connected but struggle to pay for service.
2. *The temporarily disconnected*: households that once subscribed but are currently without service. They might well resume service if an economic challenge they are currently experiencing ends, or if a subsidy program helps offset the monthly service cost.
3. *The disconnected*: those who have not previously subscribed to service at home. Some in this category may use the internet in public or private places other than home. Many in this category are older adults who have insufficient digital skills to make a residential subscription worthwhile.

This discussion suggests that ACP was a response to a multifaceted problem that affects different low-income households in different ways, depending on factors such as previous internet experience, digital skills, the availability of low-cost services, and the connectivity options available in the community. A December 2023 survey of ACP recipients found that 22% never had internet prior to enrolling, and an additional 33% only had internet in the months they could afford it (FCC, 2024b). Affordability is a complex issue that cuts across three categories of the digital divide spectrum, and that intersects with other factors such as digital skills and the availability of affordable broadband plans.

3. Incomplete participation in government benefit programs

The fact that many households eligible for benefit programs such as ACP do not sign up for them often puzzles researchers and policymakers. Why are benefits so often unused? The literature offers three different explanations: 1) lack of awareness about the program or uncertainty about eligibility; 2) the so-called hassle cost involved in obtaining program information, submitting applications, certifying eligibility and obtaining benefits; 3) the so-called benefits stigma associated with program participation (Ko & Moffitt, 2022).

Lack of awareness is particularly relevant for newly established programs such as ACP. This is compounded by the fact that information about government benefits is often transmitted through personal networks (similar to learning externalities in technology adoption, discussed below). Survey studies show that awareness about the ACP remained low (less than 50%) among eligible households even a full year after the program's inception (Education SuperHighway, 2022; Whitacre et al., 2023). These surveys also suggest misinformation and mistrust among potential recipients, which combine concerns about sharing sensitive personal information with the federal government and concerns about future rate increases.

The literature also identifies the administrative burden of signup, (re)certification of eligibility and delivery of benefits as a key barrier to enrollment. Previous studies have found that direct personal assistance for enrollment increases program uptake significantly more than the simple provision of program information to potential recipients (Finkelstein & Notowidigdo, 2019), and proximity to social service field offices or other locations where enrollment support is available has also been found to affect program uptake (Deshpande & Li, 2019). In the case of ACP, there was evidence that the administrative burden of enrollment is high for many potential recipients. For example, the Universal Service Administrative Company (USAC), which administers the ACP on behalf of the FCC, reported that most applicants (approximately 70%) whose eligibility is not automatically verified through the National Verifier do not follow up on their application.¹

Benefits stigma is the most controversial of the explanations for low participation in government benefits programs. The main hypothesis suggests that potential recipients will not participate in assistance programs due to concerns about violating social norms – particularly when participation is visible to peers (Moffit, 1983). In the original formulation, welfare stigma represents a psychological cost to potential recipients and is more likely to surface when benefits involve recurrent transactions, such as the case of “food stamps” (SNAP program). However, the original formulation of the benefits stigma hypothesis has been challenged by recent work which underscores that visibility is not a necessary condition for the activation of stigma. This line of work argues that benefits stigma can also occur when individuals internalize negative social stereotypes and attitudes towards the stigmatized group (Crocker et al., 1998; Link & Phelan, 2001). This type of stigma is closely related to individual self-esteem, and activates threats to one's perceived group identity. For example, potential ACP recipients may believe the program is not for “people like them” or that it reflects personal failure or lack of individual effort.

Studies also suggest that the intensity of social stigma is context-dependent, and varies with the extent to which others in the relevant personal networks adhere to negative attitudes about welfare, the strength of cohesion in local communities, and the extent to which peers participate in the program. For example, using administrative records linked to ACS data, Celhay et al. (2022) show that underreporting of program participation in SNAP decreases as the share of SNAP participants in the census tract of the respondent increases, empirically validating the link between welfare stigma and local social norms.

The extension of the benefits stigma hypothesis is relevant to our study because ACP participation was, for the most part, not visible to others. This is why stigma is rarely addressed in the (relatively small) literature on the determinants of participation in telecommunications subsidy programs such as Lifeline. Generally speaking, these studies build on the fact that Lifeline is a joint federal-state program, thus allowing for state-level variations in benefit amount, eligibility criteria and covered services, among other factors. Exploiting these variations, scholars have identified a number of factors that affect Lifeline uptake, including the size and scope of benefits, outreach efforts by participating providers and program longevity, along with traditional demographic determinants such as income, education, age, and participation in other safety net programs (Burton et al., 2007; Hauge et al., 2008).

4. Technology adoption: the social dimension

Perhaps the earliest example of how social networks influence technology adoption is the telephone. The very early days of the telephone industry proceeded on the premise that the phone would be a business productivity tool (Fischer, 1992, pp. 66–67). Sales brochures stressed efficiency, time savings, and the effect on customers who would see a business with a telephone as technologically savvy. But customers had other ideas. Much to the surprise of early telephone companies, the household telephone became a tool for chat, mainly for women managing households in the 1920s. The expense of long-distance service at the time means that most of this chat was among people living in close proximity.

The link between interpersonal communication and technology adoption has persisted in the computer and internet age. As the computer moved from being a household appliance for the well-off in the 1980s to a networked device in the 1990s, email became the collateral app that helped spark computer adoption, much as voice chat helped foster telephone adoption. Email was, in the early 1990s, an “unprofitable and technically uninteresting feature” for early internet service providers. AOL's success was in part due to email – appealing to consumers' interest in communicating with one another (Sproull, 2000).

Empirical work from the late 1990s reinforces this point. Analysis of government survey data from 1997 found that households were more likely to have a home computer if they lived in an area where nearby households had computers. Email users – at a time when its use was far from universal – had the greatest likelihood of having computers. The findings suggested the presence of “learning externalities,” i.e., that those nearby exploring a new technology may, tacitly or not, demonstrate to others its virtue (Goolsbee & Klenow, 2002). Trust is undoubtedly part of learning externalities; recognizing that people you know are using a novel technology helps people overcome uncertainties about trying something new.² In fact, one study documented that the early rural-urban divide in internet access was due more to “network externalities” associated with having other users nearby than to physical infrastructure

¹ Source: USAC (National Verifier data for Q2 2023).

² This ties into several of Rogers' (1962) factors that influence adoption of an innovation, namely observability and compatibility.

(Whitacre & Mills, 2007).

There is also more recent evidence of the role of learning externalities for new internet adopters. A 2014 study of Comcast Internet Essentials customers – that is, low-income households who enrolled in the company’s discount internet plan – asked respondents whether all or most of those they know had internet access at home. Those who answered “yes” were more likely than those who did not to use the internet several times a day – by a 66%–51% margin (Horrigan, 2014). This “social effect” carried through to accessing government services or using the internet to look for a job. Indeed, Zuo (2021) uses data on the Internet Essentials program to document its role in increasing employment and earnings among eligible individuals.

Further, the ACP Outreach Grant program announced in early 2023 emphasized “coordination with trusted messengers and leaders from underserved communities” in awarding funds to help with outreach efforts (FCC, 2023b). Working with trusted community partners could be seen as a strategy to address the social dimension of this work.

In sum, there is increased scholarly attention to the role of both physical spaces (neighborhoods, workplaces and so forth) as well as the social spaces in shaping individual preferences for Internet adoption and use. These spaces determine, for example, whether support is available when learning a new technology (Courtois & Verdegem, 2016) or what technology uses are socially acceptable (Helsper, 2021). DiMaggio and Garip (2012) propose a distinction between a) network externalities, in which the value of adoption increases with the number of prior adopters; b) social learning, when peers offer support for adoption; and c) normative influence, which refers to the system of social norms (for example, social rewards or penalties) associated with technology adoption. This study aligns with this literature by exploring the role of local anchor institutions and social cohesion in predicting ACP uptake (section 5.1). Further, it probes into the geographic variations of these local determinants (section 5.2).

An additional way to think about the social dimension of technology is through the concept of social capital, which refers to social ties people have that may facilitate problem-solving at the community level. It came into popular usage as Robert Putnam documented the withering of people’s participation in informal or formal community groups – the “bowling alone” phenomenon. Putnam (1992) describes social capital as “features of social organization, such as trust, norms, and networks, that can improve the efficiency of society” (at 167).

In the context of this study, social capital could potentially serve as a catalyst to ACP enrollment. Both internet adoption and the uptake of government benefit programs require overcoming barriers that social capital may mitigate. For example, the welfare stigma that potential beneficiaries may perceive could ease in the presence of community norms that legitimize participation in such programs. Many non-internet users cite concerns over sharing personal data as a reason they do not subscribe to service; trusted institutions such as public libraries or religious organizations may provide support that ease these concerns (Horrigan, 2021a). The analysis below probes into the role of social capital as a driver of ACP enrollment.

5. The ACP prediction tool model

The research cited above underscores the connection between demographics, location and the use of computers and the internet. For these reasons, this paper approaches the study of ACP participation in two related ways. First, it builds a predictive model of ACP enrollment at the 5-digit zip code level that models participation as a function of social, economic, and demographic factors. This results in global parameter estimates that quantify the partial effect of each factor on ACP uptake. Second, using the same dataset, the study implements a geographically weighed regression that derives local parameters at the zip code level. This allows for examining spatial variations in how each of the factors affected ACP participation, uncovering area clusters of high or low performance associated with different policy levers.

The factors included in the estimation models are.

- **Socio-economic characteristics:** The model uses American Community Survey (ACS) 5-year estimates (2017–2021) for information on the share of household heads that are not in the labor force, not employed, with incomes under \$15,000 annually, with children under the age of 18, over the age of 65, with college degrees or more, high school graduates or less, foreign born, rent burdened (i. e., paying more than 30% of income for rent), and that moved from a different county in the past year. It also includes the share of households with teens not in school and not working, as well as the share of unoccupied homes in an area. The number of ACP-eligible households is estimated using 200% poverty level rates from the ACS and state-level adjustment factors for other social program participation documented in Galperin (2022).
- **Digital tools:** The model uses ACS 5-year data on the share of households with wireline broadband subscriptions at home, the share of households that rely only on cellular data for home internet, and the share of households without computers. Note that this data precedes the ACP (and largely EBB) rollout and will not capture subscriptions or computers obtained via those programs.
- **Libraries:** Data from the Institute for Museum and Library Services shows whether the main branch of a public library is located in a particular zip code. The model includes a dummy variable for this metric.
- **Other:** The model includes data on the degree of rurality for a given zip code (on a scale from 1 to 9, with 9 the most rural (United States Department of Agriculture Economic Research Service, 2020)), the share of population that is Native American, Black, and Hispanic, and the number of Lifeline service providers in a zip code. It also controls for state fixed effects, that is, it includes a dummy variable for each state in order to capture unobserved characteristics specific to each state.

Appendix A provides summary statistics and sources for each variable noted above.

The global model is first estimated via ordinary least squares (OLS) with the equation:

$$y_i = \beta_0 + \sum_{k=1,m} \beta_k X_{ik} + \gamma_s + \varepsilon_i \quad (1)$$

The dependent variable y_i is the number of ACP-enrolled households divided by the number of ACP-eligible households in zip code i as of January 2024. X_{ik} denotes the values for independent variable k for zip code i (itemized in the above list) and β_k are the associated parameters; γ_s is a vector of dummy variables for state s , and ε_i is the normally-distributed error term. Under traditional OLS assumptions, the parameters are assumed to hold their relationship globally: for example, the presence of a local library impacts ACP participation the same way across the entire U.S.³ For many of the independent variables listed, however, this assumption may not be valid, perhaps due to local circumstances including culture, geography, and knowledge (Fotheringham et al., 1998). For example, some libraries have better reputations than others and may have been more influential in helping local residents sign up for the ACP.

To address this nonstationarity over space, Brunson et al. (1996) were among the first to propose a geographically weighted regression (GWR) technique. Equation (1) above transforms to:

$$y_i = \beta_{i0} + \sum_{k=1,m} \beta_{ik} X_{ik} + \varepsilon_i \quad (2)$$

The key difference is that each zip code i now has its own set of local parameter estimates, implying that the relationships in question are no longer global in nature. These parameter estimates are compiled using a set of “nearby” geographies: in practice GWR finds the optimal bandwidth for which neighbors to include by assessing a goodness-of-fit measure when the bandwidth is varied (Brunson et al., 1996).⁴ Traditional significance tests on these parameters can also be performed, allowing for maps demonstrating where the relationships do and do not hold (Brunson et al., 2002).

5.1. Global model results

Table 1 shows results for an OLS model run for 24,927 zip codes in the ACP Performance Tool database. As noted above, the dependent variable is the number of ACP enrollees divided by the total number of eligible households in each zip code as of January 2024. The number of eligible households is determined through analysis of American Community Survey data that uses the eligibility criteria that the ACS provides (i.e., population using SNAP, receiving SSI benefits, population at or below 200% of the Federal poverty level, and population using Medicaid) to develop an estimate for ACP eligibility that varies by state (Galperin, 2022). The analysis excludes zip codes with population less than 150, because such places lack reliable American Community Survey data that are key model inputs. Robust standard errors are used because initial results demonstrated evidence of heteroskedasticity.

The “unstandardized coefficients” are the basic model results, while “standardized coefficients” permit comparison of the relative magnitudes of the effects of parameter estimates. For example, the share of households headed by Blacks in a given zip code has a stronger predictive impact on ACP enrollment than the share of Asian headed households, even if both are positive. Similarly, one would expect that areas with a large share of college graduates would not enroll in ACP at a high rate. The model shows this, but it also shows (to a similar negative degree) that this is true for places with a large share of households headed by foreign born individuals. Indeed, the unstandardized coefficients imply that a 10% increase in share of households with college degrees or foreign-born individuals would lower ACP enrollment rates by 2.56% and 3.69%, respectively.

Several results may be of interest to policymakers. First is the finding for libraries. The presence of a main branch of a public library in a zip code had a positive association with ACP enrollment. One way to quantify the impact of the presence of a main library branch in a zip code is to compare ACP enrollment assuming libraries were pervasive in all zip codes (that is, the variable value is set to 1 in zip codes where there are no libraries). This shows a 3% library impact, meaning ACP enrollment would be 3% greater if we assume the library effect is pervasive – or about 600,000 additional ACP subscribers. This demonstrates the importance of these community institutions and digital navigators, which are often found in libraries (Balboa et al., 2021) in helping to reduce administrative burdens and increase program outreach activities.

Second, the model shows that economic distress is associated with higher ACP enrollment. The variable representing the percent of households with incomes below \$15,000 annually is positive and significant, and the standardized coefficient implies that a one standard deviation increase in this variable would result in a 0.05 standard deviation increase in the ACP enrollment ratio. Even after limiting the dependent variable to only those households eligible for the ACP and controlling for many other variables (as this analysis does), the share of homes in severe poverty also has a strong positive correlation with enrollment. The individual determinants of ACP eligibility matter, but so does the broader context of poverty.

Third, higher shares of minority groups are associated with higher ACP enrollment rates, but foreign born and older Americans are not. The results show significant correlations between areas with larger shares of Hispanics, Asians, and (especially) Blacks and ACP enrollment. However, areas with large concentrations of older households and households headed by foreign-born residents tend to have lower levels of ACP enrollment. Lower levels of ACP participation in areas with more foreign-born residents may reflect misinformation about eligibility (which does not depend on immigration status) as well as concerns about sharing personal data with federal government agencies. Lower enrollment in areas with higher shares of those over the age of 65 likely speaks to digital skill and

³ OLS also assumes that no spatial autocorrelation exists in the error term. If such autocorrelation does exist, it would make the associated OLS parameters either biased or inefficient (Rubin, 1998).

⁴ The Akaike Information Criterion (AIC) is often used for this purpose.

Table 1
OLS results – number of ACP enrollees/ACP-Eligible households.

	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig. (p- value)
Constant	0.275	0.020		13.742	0.000
% of households with income under \$15K annually	0.157	0.026	0.051	5.95	0.000
% of households with children under 18	-0.196	0.023	-0.060	-8.50	0.000
% of households headed by those 65 and older	-0.237	0.025	-0.090	-9.62	0.000
Main library branch in zip code area (dummy)	0.010	0.002	0.023	4.51	0.000
% of households with wireline broadband subscriptions	0.189	0.013	0.169	15.05	0.000
% of households with cell data plans as only internet subscription	0.009	0.020	0.030	0.41	0.682
% of households with no working computers	0.080	0.028	0.026	2.89	0.004
% of households headed by Hispanics	0.195	0.015	0.164	12.95	0.000
% of households headed by Blacks	0.311	0.009	0.249	33.49	0.000
% of households headed by Asians	0.403	0.027	0.128	14.75	0.000
% with household head who is a college graduate	-0.256	0.010	-0.219	-25.21	0.000
% with household head who has high school degree or less	0.072	0.025	0.029	2.83	0.005
% of teens not in school or not working	-0.006	0.006	-0.006	-0.99	0.323
% of households headed by foreign born individual	-0.369	0.027	-0.185	-13.77	0.000
% unemployed	0.204	0.036	0.041	5.59	0.000
% not in labor force	-0.013	0.018	-0.006	-0.65	0.515
% of unoccupied households	-0.001	0.011	0.000	-0.11	0.914
% of rent-burdened households	0.000	0.019	0.000	0.01	0.992
% of households that moved out of county in last year	-0.217	0.019	-0.073	-10.22	0.000
Rural scale (1–9)	-0.005	0.001	-0.067	-9.38	0.000
Number of lifeline wired carriers	0.005	0.001	0.023	3.35	0.001
Number of lifeline wireless carriers	0.020	0.001	0.382	38.57	0.000
Adjusted R² = 0.441					

Number of observations = 24,927.

program awareness issues for this cohort.

Fourth, rural zip codes and lower ACP enrollment rates are correlated, but higher rural eligibility levels help compensate. The model predicts that areas with households not adjacent to metro areas (or large population centers) have lower levels of ACP enrollment. This may partly reflect constraints in the supply of ACP-supported services in these areas (i.e. fewer providers to offer and market the program). However, additional analysis shows that a slightly higher share of rural ACP households have enrolled in ACP than non-rural ones – and this is mainly because more rural ACP households are eligible for the benefit (Horrigan, 2023). That, in turn, is a result of a higher share of rural households falling into the “at or below 200% FPL” category (by a 36%–28% margin).

Fifth, ACP enrollment rises with the share of households with wireline subscriptions and no computers. The model takes into account whether an area has a high share of households with wireline broadband subscriptions (i.e., DSL, cable, or fiber as the American Community Survey asks), as well as whether an area has a high share of households reliant only on cell data plans for service (which is more prevalent in lower-income households who cannot afford wireline service). Areas with a high share of wireline subscriptions show a positive association with ACP enrollment as do (perhaps surprisingly) areas with high shares of households without computers. It appears that two things may be happening at once: lower-income households with wireline broadband are using ACP to defray subscription costs, while some households without computers may be taking advantage of the \$100 device ACP benefit. The data on ACP enrollment does not differentiate precisely how the benefit is used (i.e., wireline, wireless, or the \$100 device benefit).

The findings above point to an additional hypothesis about ACP enrollment, namely that social capital may play a role in encouraging people to seek out the benefit. The ties people that individuals and families form in the community – either with neighbors, friends, or co-workers – may serve as a pathway to enrollment. The findings for libraries and areas with large shares of those in severe poverty are suggestive of this hypothesis. Even after accounting for eligibility status, it appears plausible to suppose that word-of-mouth in very low-income communities, perhaps with public libraries as communications channels, can influence enrollment decisions.

There has been work in recent years that examines the geography of social capital that is relevant in assessing ACP enrollment. Chetty et al. (2022) used data from Facebook and other sources to examine social capital and economic mobility at the 5-digit zip code.⁵ Building on this work, we use two distinct measures of social capital: (1) “economic connectedness,” which characterizes the extent of relationships between high socio-economic status (SES) individuals and low SES individuals; and (2) “civic organizations,” which measures participation in civic organization or volunteering groups). Both metrics are compiled using Facebook data from 2018. Notably, Chetty et al. (2022) found economic connectedness (but not civic engagement) to be a significant predictor of economic mobility.

⁵ See <https://opportunityinsights.org>.

Appendices B (economic connectedness) and C (civic organizations) show the results including these two additional predictors.⁶ Due to data limitations and privacy concerns (that is, the need to ensure that cases in the dataset could not identify specific individuals), a subset of the sample (18,275 observations) is used for Appendix B, with about 6,600 zip codes excluded. Interestingly, the models find a negative and statistically significant result between ACP adoption and economic connectedness (Appendix B) but no significant relationship with civic organizations (Appendix C).

On its face, this negative relationship with economic connectedness is curious. If, as Chetty et al. (2022) find, economic connectedness has a positive relationship with upward economic mobility, it seems inconsistent that it is negatively correlated with ACP enrollment. Notably, there is a strongly positive ($r = 0.50$) correlation between the economic connectedness measure and wireline broadband adoption in the data – suggesting that social capital is important for broadband subscription levels. The apparent anomaly in the negative relationship with ACP enrollment may be related to the underlying data used to construct the economic connectedness measure. First, it relies on Facebook data from 2018, when about 70% of U.S. internet users said they used Facebook. However, lower-income individuals are consistently much less likely to use Facebook (Schaeffer, 2024). Similarly, and perhaps most critically, the construction of the economic connectedness variable depends on having internet access and a certain degree of online literacy. Setting up a Facebook account likely means having steady access to an online pathway, even if it is not necessary to have service at home or a mobile device to do so. Using Facebook also means sharing personal data, which individuals with limited Internet literacy are often reluctant to (Helsper, 2021), and thus resulting in selection bias. Finally, the lack of a significant impact of the civic organizations measure (Appendix C) suggests that the already-included variables (library presence, economic distress, racial/ethnic characteristics) may be capturing this variation.

5.2. GWR model results

As discussed above, OLS assigns a single parameter estimate (a “global average”) to each characteristic regardless of its geographic location. The alternative approach provided by GWR allows these estimates to vary over space, implying that the responses to changes in the characteristics themselves would also vary across space. The underlying intuition in moving from OLS to GWR is that the global average may not reflect the actual response for many geographies. Demonstrating these relationships visually provides important information about how policy suggestions might fare across different regions. An early paper on this topic found that a standard global approach would have significantly underrepresented the spatial differences for about two-thirds of the variables examined, and that global policy suggestions would likely have been poorly suited for many local areas (Ali et al., 2007).

Table 2 presents the global and median parameter estimates for a GWR model (with ACP enrollment per household as the dependent variable, as in Table 1) that includes 25,026 zip codes in the continental U.S. The table also includes the percentage of zip codes that have statistically positive and negative relationships at the $p < 0.05$ level. These columns demonstrate how a global average often masks significant variation across regions.

The standardized OLS (global) coefficients in Table 2 are similar (but not identical) to those from Table 1, although the adjusted R^2 is somewhat smaller (0.289 vs. 0.441). This is because the state fixed effects and the rural-urban continuum codes were removed from this specification since they are not relevant in the GWR context. The GWR value for the adjusted R^2 (0.599) demonstrates a large improvement over the global regression, as expected. The median GWR parameter estimate is often similar to its global counterpart. Notably, however, nearly all variables in the GWR model have relationships that vary between positive and negative across zip codes. For example, while the global estimate for percentage of households with incomes under \$15,000 is strongly positive, 4 percent of zip codes demonstrate a statistically significant negative relationship with this variable, compared to 7.5 percent with a positive one. A large proportion of zip codes have no meaningful relationships with many of the variables being assessed – for example, the percentage of residents over 65 is only significant for around 19 percent of zip codes (2.5% positive and 16.5% negative). This suggests that outreach policies emphasizing specific characteristics are not likely to be universally effective.

The parameter estimates for several of these variables are mapped in Fig. 1 to provide additional insight. Zip codes with standardized coefficients that are significantly positive (negative) at the $p < 0.05$ level are shown in green (red), with darker colors representing numerically larger coefficients. Several maps demonstrate patterns that are strong across most of the U.S. For example, the percentage of black residents is positively associated with ACP enrollment for over 82 percent of all zip codes and the percentage of households with a wireline broadband connection is positive for 51 percent. Other relationships vary dramatically across space, with significant portions of the country responding both positively and negatively.

As an example, the percentage of foreign-born residents is negatively associated with ACP enrollment in large portions of Oklahoma, Colorado, Michigan, and Mississippi. Conversely, this same variable has a positive relationship in portions of Kentucky, New York, and Maine. Similar differing relationships are seen for the percentage of residents that are Hispanic and older than 65. These results broadly imply that local context should be an important consideration when creating policies attempting to promote ACP enrollment. Note, however, that an area with a negative relationship for a specific characteristic does not mean that ACP outreach focusing on that characteristic should be ignored. Instead, these areas represent an opportunity for turning things around by varying the outreach approaches used to date.

⁶ The two variables are not both included in the same model because of the high number of excluded zip codes for the economic connectedness variable.

Table 2
GWR results – number of ACP enrollees/ACP-Eligible households.

	Standardized (Global) OLS Coefficient	Sig. (p-value)	Median GWR Coefficient	% Positive (p < 0.05)	% Negative (p < 0.05)
Constant	0.000	1.000	−0.046	25.5	32.1
% of households with income under \$15K annually	0.047	0.000	0.002	7.5	4.3
% of households with children under 18	−0.123	0.000	−0.003	1.3	17.9
% of households headed by those 65 and older	−0.149	0.000	−0.043	2.5	16.5
Main library branch in zip code area (dummy)	0.023	0.000	0.033	23.2	3.3
% of households with wireline broadband subscriptions	0.236	0.000	0.145	51.7	1.4
% of households with cell data plans as only internet subscription	0.013	0.141	0.020	11.7	8.8
% of households with no working computers	0.014	0.101	0.024	14.5	5.1
% of households headed by Hispanics	0.063	0.000	0.120	25.7	4.3
% of households headed by Blacks	0.282	0.000	0.377	82.2	0.3
% of households headed by Asians	0.061	0.000	0.087	23.2	2.3
% with household head who is a college graduate	−0.165	0.000	−0.166	3.2	53.5
% with household head who has high school degree or less	0.072	0.000	0.031	15.2	6.3
% of teens not in school or not working	0.002	0.744	0.000	6.6	5.8
% of households headed by foreign born individual	−0.085	0.000	−0.166	3.0	25.7
% unemployed	0.064	0.000	0.022	14.8	3.8
% not in labor force	0.070	0.000	−0.063	2.8	24.3
% of rent-burdened households	0.053	0.000	−0.021	8.3	15.2
% of households that moved out of county in last year	−0.121	0.000	−0.051	2.4	19.5
Number of Lifeline wired carriers	0.036	0.000	0.010	20.5	8.9
Number of Lifeline wireless carriers	0.205	0.000	0.275	74.1	4.3
Adjusted R²	0.289		0.599		

Number of observations = 25,026.

6. Conclusion and policy implications

The results of this study suggest several opportunities for adjusting ongoing initiatives and designing new direct support programs for broadband that should be of interest to policymakers at different administrative levels (federal, state, county and even more local) as well as to other stakeholders. The positive correlation between ACP enrollment and areas with a large share of households in severe poverty underscores the social dimension in ACP enrollment decisions. Since not all eligible households were enrolled in ACP, it is likely that “early adopter” households conveyed information through local networks about the program’s benefits. This may have encouraged other low-income households to enroll sooner than they might otherwise.

The role of social capital, as captured through economic connectedness, comes into play in indirect and non-intuitive ways. There is a positive relationship between levels of wireline broadband and social capital, suggesting that social capital perhaps plays a role in overcoming non-price barriers to adoption. Yet this factor also has a negative correlation with levels of ACP enrollment; this result may be due to the economic connectedness variable itself being premised on Facebook use. An alternative interpretation is that social capital, by helping vulnerable households overcome other barriers to adoption, reduces the need for subsidy programs targeting affordability barriers.

The results also show that housing costs have inhibited ACP enrollment (when controlling for social capital). Many ACP enrolled households paid for service even after the \$30 discount (Whitacre et al., 2023), and the model finds a negative relationship between “rent-burdened” areas and enrollment. As Galperin and Huang-Isherwood (2022) show, local housing policies addressing rent-burden may also encourage families to subscribe to low-cost internet programs – which the FCC partly embraced by establishing a pilot program to fund ACP outreach through local housing authorities and housing advocacy organizations (titled “Your Home, Your Internet”) (FCC, 2022).

Further, the results indicate that anchor institutions can facilitate enrollment, as seen in the positive association between the presence of public libraries and ACP enrollment rates in a given area. Previous studies have shown that, despite continued growth in residential and mobile broadband adoption, libraries continue to play a key role as a connectivity alternative in low-income areas, offering not just physical infrastructure but digital skills training and other related services (Hosman & Comisso, 2020; Strover et al., 2020). Our results corroborate these findings and add a new dimension to the role of public libraries as conduits of information and support for ACP enrollment through “digital navigator” and similar initiatives. Notably, preliminary versions of the Digital Equity Act plans from many states include plans for funding digital navigator efforts through libraries (National Telecommunications and Information Administration, 2023). Again, in light of ACP’s demise, this finding underscores the role for digital navigators in helping people find discount offers. A recent survey of ACP enrollees found that 29% would drop their service if their monthly bill increased by \$30 per month, suggesting that many households will need help finding such offers (FCC, 2024b).

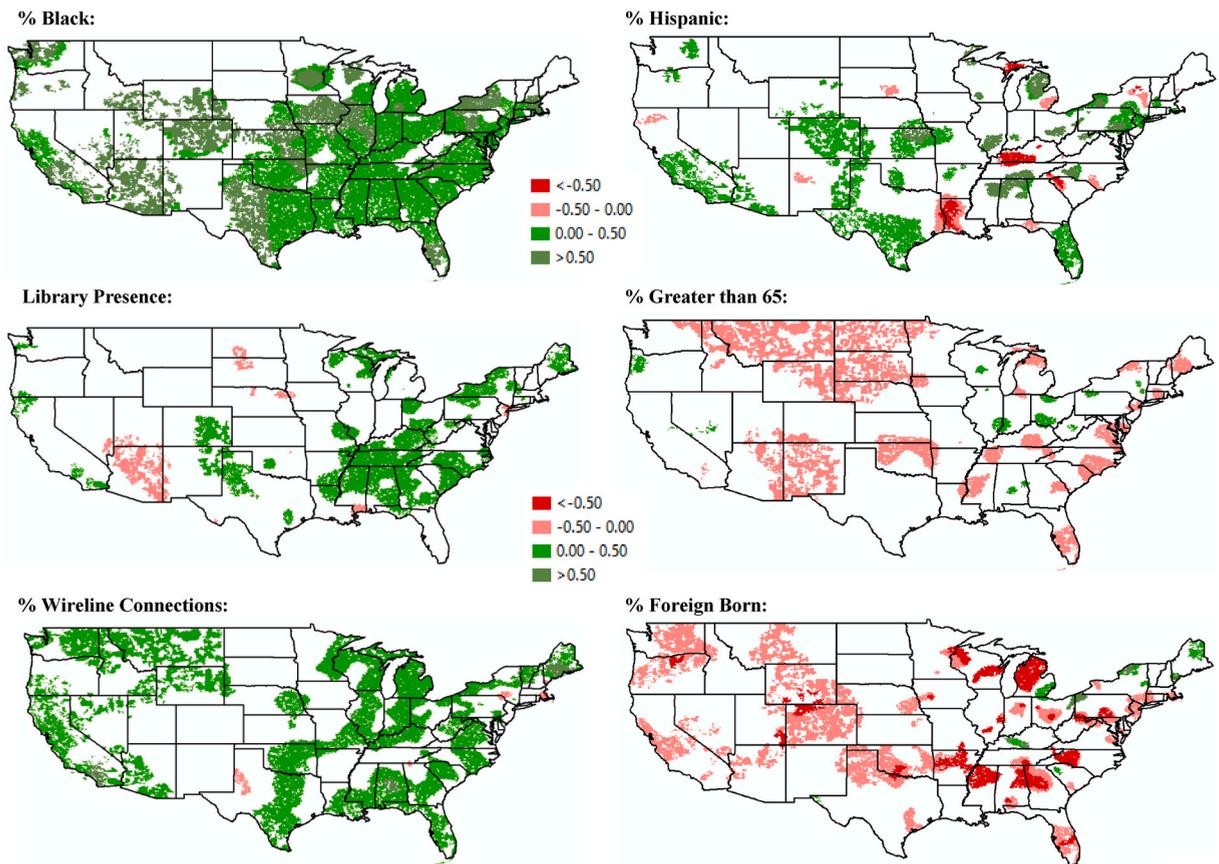


Fig. 1. Geographically weighted regression standardized parameter estimates for selected variables.

Turning to geographical variations, our results suggest an opportunity for further encouraging ACP uptake in rural areas, even if these areas have several intrinsic disadvantages, such as less dense social networks and fewer anchor institutions. While the results indicate that factors that relate to population density (such as the presence of anchor institutions and the number of broadband service providers) are associated with higher ACP enrollment, rural areas tend to have a higher share of eligible households (Whitacre & Song, 2024). Tapping into trusted institutions in rural areas for outreach, such as agricultural extension services, is a strategy that could accelerate enrollment in such contexts.

The GWR results provide strong evidence that the relationships between ACP enrollment and local characteristics are context specific. Only a few factors (% Black, % with wireline connections, number of Lifeline wireless carriers) consistently predict higher levels of ACP enrollees across most of the U.S. Others (% with high school degree or less, % unemployed, % with children, % headed by Hispanic, Asian, or foreign-born individuals) show pockets of the country with both positive and negative relationships with ACP enrollment. An understanding of how (and why) these relationships might vary across geographies will be important for crafting policies geared towards increasing uptake of any future iteration of this program. Popular press articles abound with examples of community partners that have played a role in encouraging ACP enrollment to date: from churches (Banks & Shimron, 2023) to digital equity organizations (Office of Educational Technology, 2023; Skukowski, 2024) to public school districts (Huffman, 2023). A more in-depth exploration of the “pockets of success” uncovered by the GWR analysis would be a fruitful avenue for future work. Emphasizing local advantages and trusted community organizations likely helped improve ACP performance, even in areas with limited success to date. Although the ACP is slated to run out of funding in May 2024, digital inclusion advocates remain hopeful that it will return with a long-term funding solution – particularly in light of recent work showing that the program returns around two dollars for every dollar spent (Horrigan, 2024; Huffman, 2024). If and when the program returns, the lessons learned from its initial version should be applied to ensure that as many eligible households as possible are helped.

CRedit authorship contribution statement

John B. Horrigan: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Brian E. Whitacre:** Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Hernan Galperin:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Data availability

Data will be made available on request.

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Appendix A. Summary Statistics and Data Sources

Variable	Mean	S.D.	Source
ACP-enrolled households/ACP-eligible households (Dependent variable)	0.347	0.192	USAC ACP enrollment tracker; ACS 2017–2021; Galperin (2022)
% of households with income under \$15K annually	0.091	0.063	ACS 2017–2021
% of households with children under 18	0.215	0.059	ACS 2017–2021
% of households headed by those 65 and older	0.194	0.074	ACS 2017–2021
Economic connectedness	0.881	0.218	Chetty et al. (2022); 18,275 observations
Civic organizations	0.019	0.027	Chetty et al. (2022); 21,535 observations
Main library branch in zip code area (dummy)	0.340	0.474	IMLS
% of households with wireline broadband subscriptions	0.642	0.173	ACS 2017–2021
% of households with cell data plans as only internet subscription	0.756	0.116	ACS 2017–2021
% of households with no working computers	0.085	0.063	ACS 2017–2021
% of households headed by Hispanics	0.108	0.163	ACS 2017–2021
% of households headed by Blacks	0.082	0.154	ACS 2017–2021
% of households headed by Asians	0.027	0.061	ACS 2017–2021
% with household head who is a college graduate	0.274	0.164	ACS 2017–2021
% with household head who has high school degree or less	0.107	0.078	ACS 2017–2021
% of teens not in school or not working	0.180	0.170	ACS 2017–2021
% of households headed by foreign born individual	0.070	0.097	ACS 2017–2021
% unemployed	0.051	0.038	ACS 2017–2021
% not in labor force	0.397	0.097	ACS 2017–2021
% of unoccupied households	0.854	0.123	ACS 2017–2021
% of rent-burdened households	0.108	0.093	ACS 2017–2021
% of households that moved out of county in last year	0.111	0.065	ACS 2017–2021
Rural scale (1–9)	3.594	2.529	United States Department of Agriculture Economic Research Service, 2020
Number of Lifeline wired carriers	1.353	0.961	USAC
Number of Lifeline wireless carriers	5.452	3.635	USAC

Number of observations = 24,927 for all variables except those from Chetty et al. (2022).

USAC = Universal Service Administrative Company; ACS = American Community Survey; IMLS = Institute for Museum and Library Services; USDA = United States Department of Agriculture.

Appendix B. OLS Results – Number of ACP Enrollees/ACP-Eligible Households with Economic Connectedness

	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig. (p-value)
Constant	0.480	0.028		17.46	0.000
% of households with income under \$15K annually	0.223	0.034	0.066	6.57	0.000
% of households with children under 18	–0.252	0.029	–0.070	–8.81	0.000
% of households headed by those 65 and older	–0.285	0.029	–0.098	–9.43	0.000
Economic connectedness	–0.307	0.010	–0.353	–29.80	0.000
Main library branch in zip code area (dummy)	0.010	0.004	0.028	4.73	0.000
% of households with wireline broadband subscriptions	0.291	0.018	0.229	16.92	0.000
% of households with cell data plans as only internet subscription	0.080	0.029	0.275	2.71	0.007
% of households with no working computers	0.113	0.036	0.030	3.09	0.002
% of households headed by Hispanics	0.169	0.018	0.151	9.84	0.000
% of households headed by Blacks	0.252	0.010	0.208	24.75	0.000
% of households headed by Asians	0.539	0.030	0.194	17.91	0.000
% with household head who is a college graduate	–0.159	0.012	–0.140	–12.96	0.000
% with household head who has high school degree or less	–0.036	0.031	–0.014	–1.15	0.248
% of teens not in school or not working	–0.027	0.009	–0.019	–3.07	0.002
% of households headed by foreign born individual	–0.459	0.030	–0.253	–15.57	0.000
% unemployed	0.116	0.045	0.019	2.54	0.010

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	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig. (p- value)
% not in labor force	-0.040	0.023	-0.018	-1.75	0.090
% of unoccupied households	0.036	0.014	0.019	2.57	0.0102
% of rent-burdened households	-0.086	0.019	-0.043	-4.44	0.000
% of households that moved out of county in last year	-0.289	0.025	-0.096	-11.18	0.000
Rural scale (1–9)	-0.008	0.001	-0.096	-12.07	0.000
Number of lifeline wired carriers	0.002	0.001	0.001	1.49	0.137
Number of lifeline wireless carriers	0.016	0.001	0.306	23.30	0.000
Adjusted R² = 0.504					

Number of observations = 18,275.

Appendix C. OLS Results – Number of ACP Enrollees/ACP-Eligible Households with Civic Organizations

	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig. (p- value)
Constant	0.239	0.023		10.30	0.000
% of households with income under \$15K annually	0.238	0.031	0.074	7.76	0.000
% of households with children under 18	-0.183	0.026	-0.053	-6.92	0.000
% of households headed by those 65 and older	-0.234	0.027	-0.084	-8.49	0.840
Civic Organizations	0.045	0.053	0.006	0.84	0.240
Main library branch in zip code area (dummy)	0.007	0.002	0.018	3.22	0.001
% of households with wireline broadband subscriptions	0.239	0.015	0.203	15.77	0.000
% of households with cell data plans as only internet subscription	0.053	0.026	0.019	2.05	0.041
% of households with no working computers	0.112	0.033	0.033	3.36	0.001
% of households headed by Hispanics	0.212	0.016	0.184	13.37	0.000
% of households headed by Blacks	0.321	0.009	0.266	34.00	0.000
% of households headed by Asians	0.438	0.029	0.147	15.32	0.000
% with household head who is a college graduate	-0.284	0.010	-0.249	-26.00	0.000
% with household head who has high school degree or less	0.079	0.030	0.030	2.74	0.006
% of teens not in school or not working	-0.019	0.007	-0.012	-2.53	0.010
% of households headed by foreign born individual	-0.401	0.028	-0.210	-14.08	0.000
% unemployed	0.241	0.043	0.044	5.65	0.000
% not in labor force	-0.010	0.021	-0.005	-0.50	0.619
% of unoccupied households	0.004	0.012	0.002	0.754	0.310
% of rent-burdened households	-0.021	0.21	-0.011	-1.02	0.307
% of households that moved out of county in last year	-0.227	0.024	-0.075	-9.48	0.000
Rural scale (1–9)	-0.005	0.001	-0.069	-9.04	0.000
Number of lifeline wired carriers	0.003	0.001	0.013	1.78	0.075
Number of lifeline wireless carriers	0.020	0.001	0.383	33.84	0.000
Adjusted R² = 0.461					

Number of observations = 21,535.

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