PERSPECTIVES

PHOENIX CENTER FOR ADVANCED LEGAL & ECONOMIC PUBLIC POLICY STUDIES

Broadband Inequality in the Era of Subsidies

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The Federal Communications Commission ("FCC") recently released results from a survey of participants in its Affordable Connectivity Program ("ACP").[1] The ACP, established by the Infrastructure Investment and Jobs Act,[2] is a broadband subsidy program providing support of $30 per month (or $75 per month for tribal areas) to lower-income households that may have difficulty paying for broadband services. These subsidies exist alongside the Lifeline Program, which offers a lower $9.25 per month subsidy for broadband service, with most Lifeline participants choosing low-cost mobile wireless plans designed specifically for the program.[3]

Funding for ACP has run out, and earlier this year the Commission closed the program to new subscribers.[4] In a matter of months, the ACP budget will be exhausted and, without new funds to replenish the program, some 23 million participants will be forced to pay full price for broadband services, tempered perhaps by migrating to a cheaper plan. In the midst of a Congressional budget dispute, the prospects for continued funding appear grim.

One barrier to renewed ACP funding is the claim that the subsidies did not do much to increase broadband adoption, since most ACP participants had broadband service before the subsidy.[5] On this question, the Commission's survey appears discouraging, with results indicating that only 21.8% (± 1.1) of households were "new" adopters. But this statistic is nearly meaningless as the Commission's survey asked whether the respondent had broadband service "before receiving my ACP benefit."

In all, the data show that broadband inequality has declined substantially during the period of subsidized connections, with some evidence pointing to subsidized pricing as a contributor.

Many ACP subscribers were participants in a host of other low-income plans including its predecessors the Emergency Broadband Benefit Program ("EBB"), the Lifeline Program ($9.25 per month, used mostly for limited-service mobile connections), and a host of low-priced offerings by broadband providers targeting low-income households since 2011 (the year Comcast's Internet Essentials began; AT&T began offering such low-priced offers in 2016).[6] Many, if not all, of the millions of participants in the providers' voluntary low-priced offerings migrated to EBB program and the ACP. Such subsidies, however, are rightfully the responsibility of government, not private firms.

Complicating matters, ACP participants might find no relief when the program's funds are exhausted.[7] If the ACP is not re-funded, discount plans offered by Internet Service Providers ("ISPs") based on income could be threatened by the plain language of Section 60506 of the Infrastructure Investment and Jobs Act (which

explicitly prevents discrimination based on *income* and thus does not allow for plans specifically targeted at "low income" consumers)[8] and the FCC's new Digital Discrimination rules.[9] Resolution of this issue remains to be litigated.

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Broadband subsidies, whether publicly- or privately funded, aim to reduce inequality in broadband adoption. Have they accomplished the task? In this PERSPECTIVE, I estimate a Gini Index for broadband adoption using data from the American Community Survey ("ACS") for years 2013-2022. While income inequality has remained somewhat constant over the period, broadband inequality has declined substantially over the years, with a marked decline beginning in 2016 when Lifeline subsidies became available for broadband service and the low-income, low-priced offers by broadband providers began in earnest.[10] If the goal of subsidy programs is to reduce inequality in broadband adoption, as some claim, then evaluating how inequality has changed over time is worth studying.[11]

Here, I find that the broadband Gini Index falls substantially over time and approaches the Gini's lower bound of zero. Meanwhile, income inequality has remained stable at approximately 0.48. In all, the data show that broadband inequality has declined substantially during the period of subsidized connections, with some evidence pointing to subsidized pricing as a contributor. The EBB and ACP programs are found to have an effect on fixed broadband adoption and also the combination of both fixed and mobile broadband connections; no effect is found for the program on inequality for mobile broadband adoption, though this seems likely due to the Lifeline Program which impacted mobile adoptions in 2016.

Data

All the data used in this analysis are ACS annual data for the years 2013 through 2022.[12] Data are obtained on household income and household broadband adoption each year. Adoption is measured by the presence of a fixed or mobile broadband connection in the household. Respondents indicating that they have broadband in the home but do not pay for a subscription are excluded (less than 4% of the sample). Households with satellite services are also excluded. While modern satellite networks offer services comparable to fixed and mobile connections, these services became commercially available only in 2021 (*e.g.*, Starlink). Satellite connections are relatively expensive and rare, this exclusion does not affect the results by a discernable degree.

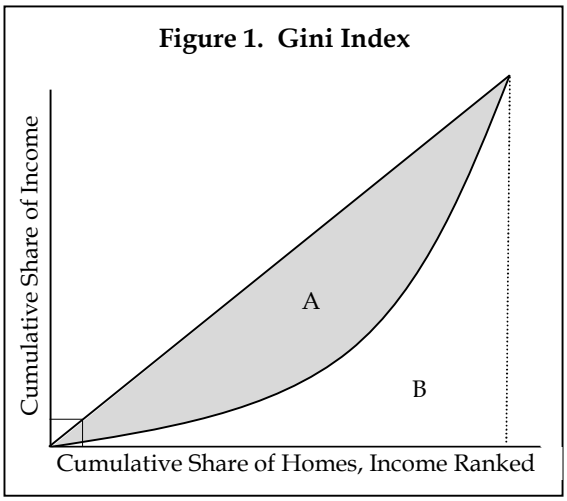
Data on EBB and ACP participation rates at the state level are obtained from USAC.[13] As the ACS data are collected throughout the year, the annual mean participation rates are used.

The samples sizes are large at roughly 1.2 million respondents annually. Note that the Census Bureau labels its 2020 ACS data as having experimental weights, reflecting the complexities of data collection during the Covid Pandemic.

Framework

The purpose of broadband subsidies is to increase adoption by lower-income households, thus reducing inequality in broadband adoption. The Gini Index is a widely-used measure of inequality. The Gini Index measures the inequality among the values of a frequency distribution, such as levels of income. A Gini Index of 0 reflects perfect equality, where all income (or some other outcome of interest) is evenly distributed across society. In contrast, a Gini Index of 1.0 reflects maximal inequality, where a single individual (or group of individuals) has all the income while all others have none. Thus, a lower Gini Index indicates more equal distribution of income or wealth, while a larger value indicates greater inequality.

Figure 1. Gini Index



The Gini Index is calculated based on the Lorenz curve, which plots the cumulative share of total income received by a portion of the population against the cumulative share of the total population. The Gini Index is the ratio of the area between the Lorenz curve and the line of perfect equality (a 45-degree line) and the area under the equality line. Figure 1 illustrates the calculation. Along the horizontal access is the cumulative share of the population ranked by income, while the cumulative share of income is measured on the vertical axis. The straight 45-degree line measures equality of income share along population share (pure income equality). The curved line is the actual cumulative share of income (the Lorenz Curve), which shows that lower-income households have a much lower share of total income than do higher-income households. The Gini Index is calculated as A/(A + B); in the figure the index would be about 0.50. For the broadband Gini Index, the vertical axis measures the cumulative share of broadband connections.

The ACP has been criticized for doing little to close the digital divide, a criticism supported by the FCC's recent survey of ACP participants that finds only 21.3% of ACP-funded connections are for households that had no broadband service prior to the subsidy. Yet, due to the phrasing of the FCC's survey question, the responses offer little policy guidance.

Results

Table 1 summarizes the Gini Index for income and fixed broadband connections over the ten-year period of this analysis. The Gini Index for income inequality is relatively stable at about 0.46, indicating substantial income inequality. In 2013, the fixed broadband Gini Index is much smaller (0.133), indicating far less inequality, and it fell substantially over the years, obtaining a value of 0.062 in 2022 (representing about a 50% drop), thus approaching the lower bound of the index.

While there is much political anxiety over inequality in broadband adoption, the relatively small Gini Index is somewhat remarkable and suggests that while lower-income households are less likely to have fixed broadband in the home, fixed broadband is not as unequally distributed as the policy debate suggests.

Table 1. Gini Index: Fixed

Year	Income	Fixed Broadband
2013	0.457	0.133
2014	0.458	0.131
2015	0.457	0.119
2016	0.454	0.119
2017	0.457	0.112
2018	0.455	0.104
2019	0.447	0.092
2020	0.449	0.071
2021	0.455	0.072
2022	0.455	0.062

The difference between the income and fixed broadband Gini Index is seen more clearly by looking at the cumulative shares upon which the index is based. Table 2 summarizes these shares for 2013 when the fixed broadband Gini Index is the largest.

Table 2. Cumulative Shares, 2013

Year	Households	Income	Fixed Broadband
10%	0.106	0.010	0.061
20%	0.211	0.034	0.126
30%	0.309	0.070	0.204
40%	0.414	0.122	0.300
50%	0.511	0.186	0.399
60%	0.610	0.266	0.508
70%	0.712	0.372	0.629
80%	0.807	0.495	0.746
90%	0.905	0.655	0.873
100%	1.000	1.000	1.000

The data are cut by income decile, so the shares of households are approximately 10% in each group. For the lowest income group, 10% of (the poorest) households account for only 1% of income, and the bottom 20% of households account for only 3.4% of income, indicating high inequality. The income shares lag population shares through the ninth decile. For fixed broadband, however, the bottom 10% of the income distribution accounts for 6.1% of fixed broadband lines, a much higher share than for income. Across all groupings, the share of fixed broadband exceeds the share of income. So, while there is some inequality in fixed broadband adoption, it is markedly less severe than for income. This same pattern is exhibited for mobile broadband (see *infra*).

Figure 2. Fixed Broadband Gini Index

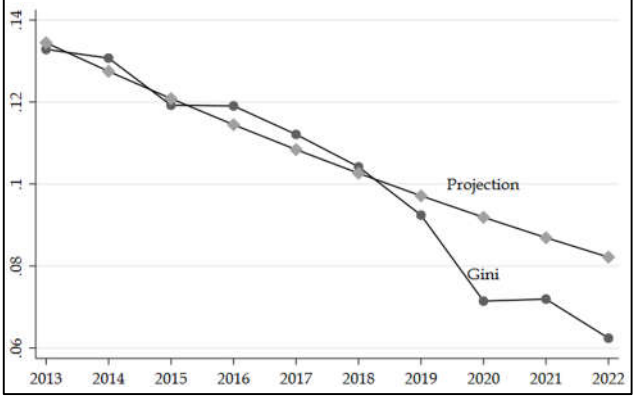


Figure 2 illustrates the trend in the fixed broadband Gini Index over time. Included in the figure is a non-linear extrapolation based on data from years 2013 through 2015.[14] This time frame is obviously a short period on which to base a projection, so we should use the resulting trend line with circumspection. With that caveat, the projection suggests that fixed broadband inequality was shrinking absent the subsidy efforts, and the Gini Index follows that trend until 2020. The marked decline in the Gini Index in 2020 presumably reflects the Covid Pandemic and possibly federal income support from the stimulus programs. Inequality rose slightly in 2021 but fell again in 2022. Covid relief, and the EBB Program and the ACP appears to have reduced broadband inequality, as inequality fell sharply in the later years when income and broadband subsidies commonly used for fixed services were initiated, though no causal link can be claimed, though the mobile results (*infra*) are informative in this regard.

Table 3. Gini Index: Mobile

Year	Income	Mobile Broadband
2013	0.457	0.195
2014	0.458	0.174
2015	0.457	0.154
2016	0.454	0.117
2017	0.457	0.101
2018	0.455	0.085
2019	0.447	0.070
2020	0.449	0.050
2021	0.455	0.051
2022	0.455	0.042

Table 3 summarizes the Gini Index for mobile broadband services, which has fallen substantially over time. In 2022, the index is roughly a quarter of its size in 2013.

Figure 3. Mobile Broadband Gini Index

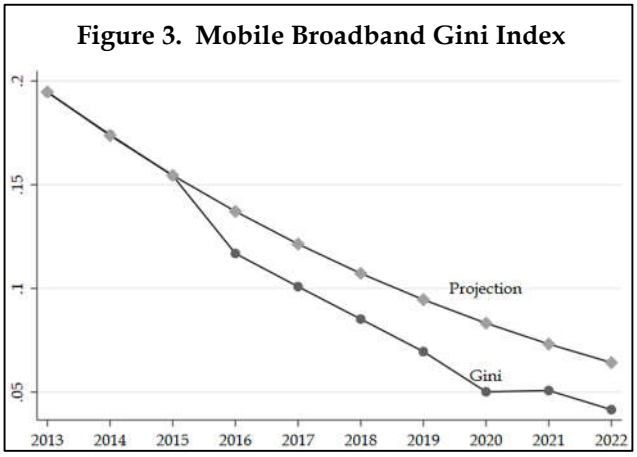


Figure 3 illustrates the trend in the Gini Index. Here, the sharp decline in inequality in 2016 likely reflects the expansion of the Lifeline Program to broadband services, where most of the participants used the subsidy to obtain free (or nearly free) limited mobile data service. As with fixed broadband, the decline in the index settles in around 2020, with a slight increase in 2021 followed by a decline in 2022.

Table 4. Gini Index: Both Modalities

Year	Income	Fixed & Mobile
2013	0.457	0.251
2014	0.458	0.232
2015	0.457	0.211
2016	0.454	0.177
2017	0.457	0.161
2018	0.455	0.143
2019	0.447	0.128
2020	0.449	0.101
2021	0.455	0.096
2022	0.455	0.083

Table 4 summarizes the Gini Index for households with both mobile and fixed connections. Again, the index is falling fast, shedding about two-thirds of its starting value over the ten years.

Figure 4. Fixed & Mobile Gini Index

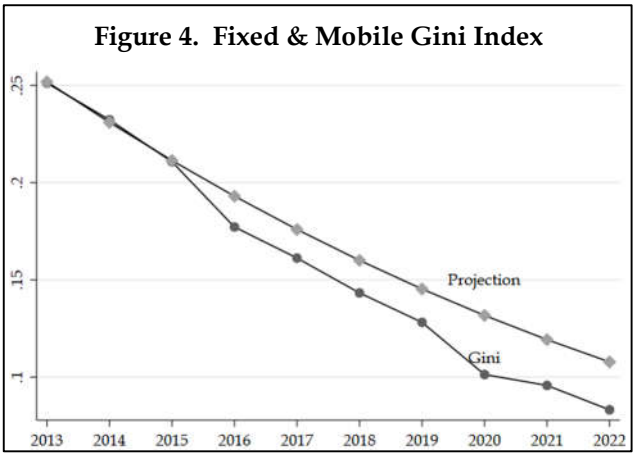


Figure 4 illustrates the trend, which falls sharply in 2016 as does the mobile Gini Index. The index is below its projections in all years following 2015.

Table 5. Gini Index: Either Modality

Year	Income	Fixed *or* Mobile
2013	0.457	0.021
2014	0.458	0.018
2015	0.457	0.017
2016	0.454	0.022
2017	0.457	0.017
2018	0.455	0.032
2019	0.447	0.027
2020	0.449	0.034
2021	0.455	0.023
2022	0.455	0.027

Finally, Table 5 summarizes the Gini Index for households having either mobile or fixed services. The Gini Index is trivially small, indicating near equality in broadband access of either a fixed or mobile modality. Most households have a connection of some sort, irrespective of income, though mobile connections, at least historically, are more limited in their ability to fully service a household, and millions of these mobile lines for lower-income households are Lifeline services. That said, modern mobile connections, such as T-Mobile's 5G Home Internet service, are very capable broadband connections and offer nearly equivalent services to fixed connections.

Effect of the EBB and ACP Programs

The trends from the figures above suggest that the subsidy programs may have favorably influenced broadband inequality over time. Here, a more formal test is conducted. A Difference-in-Differences ("DD") model is estimated,

$$G_{it} = \delta S_{it} P_{it} + \alpha Y_{it} + \lambda_t + \mu_i + \varepsilon_{it}, \qquad (1)$$

where G_{it} is the broadband Gini Index for state i in period t, S_{it} is the number of mid-year EBB or ACP participation rate in the state (as a share of total population), P_{it} is a dummy variable for years after 2020 when these subsidy programs were available, Y_{it} is the income Gini Index, λ_t and μ_i are year and state fixed effects, and ε_{it} is the econometric disturbance term. Standard errors are clustered at the state level.

The expectation is that α will be positive and less than 1.0—broadband inequality is positively related to income inequality but more equal than the income distribution. If not, then low-income subsidies would be difficult to justify. The δ coefficient (the DD coefficient) will be negative if the subsidies reduce broadband inequality. Note that the mean of Y_{it} is 0.45 with a range of 0.38 to 0.50, and the mean of S_{it} (in 2021 and 2022) is 0.104 with a range of 0.025 to 0.183. Roughly half of ACP subscriptions were for fixed broadband, and a large share of mobile-only households (39%) used the subsidy to obtain fixed services.[15]

Table 6. Broadband Inequality and Subsidies

	Fixed	Mobile	Both
α	0.400***	0.302***	0.404***
	(4.19)	(2.82)	(4.14)
δ	-0.272***	-0.069	-0.256***
	(-4.92)	(-1.32)	(-4.05)
Obs.	510	510	510
F-Stat	30.81***	5.18***	20.85***

Stat Sig. *** 1% , ** 5%, * 10%

Results are summarized in Table 6. For fixed broadband service, broadband inequality rises with income inequality (0.40), and the larger number of subsidy participants reduces inequality (-0.272). At the mean of S_{it}, the subsidy programs reduced the fixed Gini Index by 0.028 (or 25%). At the highest S_{it}, the effect size is 0.05, or a 44% reduction in the index.

The estimated coefficients are roughly the same for both modalities (0.404 and -0.256), driven mainly by fixed connections. At the mean of S_{it}, inequality fell by 15.8%, while at the maximum of S_{it} it fell by 27.4%. For mobile services, the coefficient on income inequality is smaller than for fixed services (-0.303) and is statistically different from zero, reflecting the relatively heavy use of mobile broadband by lower-income

households.[16] The effect of subsidy participation is small (-0.069) and statistically no different from zero (though the t-statistic is well above 1.0). These results comport with Figure 3 above. At the mean of S_{it}, broadband inequality fell by 6.2%, while at the maximum of S_{it} inequality fell by 10.9%. The Lifeline Program appears to have reduced broadband inequality sufficiently (with a sizable shift in 2016) so that the EBB and ACP programs had little effect on mobile broadband inequality, though the popular low-price Lifeline plans offer only limited services (but still count toward adoption in the data). The "quantity" and "quality" of mobile services for participants likely increased since the EBB and ACP subsidies allowed participants to obtain a standard mobile wireless plan.

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An interesting extension of Equation (1) permits the relationship of the broadband Gini Index to the Income Gini Index to vary over time where α becomes a vector of coefficients (one for each year), the values of which are summarized in Table 7. In the early years, the relationship between broadband and income equality is strong, with α coefficients around 0.50. A sharp reduction in the relationship occurs in 2020 and persists through 2022. For both mobile and both services, the relationship between broadband and income equality is severed (the effect sizes are not statistically different from zero). Similarly, for fixed broadband, though the relationship remains statistically different from zero, the t-statistics are smaller.

Table 7. Broadband & Income Inequality

	Fixed	Mobile	Both
2013	0.656***	0.549***	0.514***
2014	0.502***	0.539***	0.541***
2015	0.508***	0.474***	0.502***
2016	0.493***	0.410***	0.498***
2017	0.524***	0.437***	0.591***
2018	0.439***	0.353***	0.500***
2019	0.411***	0.371***	0.486***
2020	0.193**	0.127	0.260***
2021	0.219**	0.090	0.140
2022	0.197*	-0.067	0.187
Obs.	510	510	510
F-Stat	7.55***	12.8***	7.34***

Stat Sig. *** 1% , ** 5%, * 10%

In all, the EBB and ACP programs have reduced inequality in fixed broadband adoption and the adoption of both fixed and mobile services, and for the adoption of both services the link between broadband and income inequality was broken while the two programs were active. While the effect of the two subsidy programs for mobile services is smaller, the link between broadband and income inequality for mobile services became much weaker (and statistically no different from zero) when the subsidies were available.

Conclusion

The ACP has been criticized for doing little to close the digital divide, a criticism supported by the FCC's recent survey of ACP participants that finds only 21.3% of ACP-funded connections are for households that had no broadband service prior to the subsidy. Yet, due to the phrasing of the FCC's survey question, the responses offer little policy guidance. Most EBB participants migrated to the ACP (thus, they had broadband before the ACP using the predecessor subsidy program), and many if not most Lifeline participants (largely on limited broadband plans) participate in the ACP. Moreover, millions of qualifying households using the low-cost offerings of broadband providers (usually less than $15/month) offered prior to either the EBB

Program or the ACP became participants in these programs. Asking a previously subsidized household whether they had broadband before the current subsidy program provides no useful data if the participants relied on other subsidy programs before the ACP.

What we do see in the data is that during the period of myriad publicly- and privately-funded broadband subsidies, broadband adoption became more equal, with fixed, mobile, and fixed and mobile services having a Gini Index lower than expectations.

What we do see in the data is that during the period of myriad publicly- and privately-funded broadband subsidies, broadband adoption became more equal, with fixed, mobile, and fixed and mobile services having a Gini Index lower than expectations. The loss of ACP funding is certain to increase inequality in broadband adoption, though by how much is unknown. While many low-income households participating in the ACP may remain online when the subsidy expires, it is undoubtedly true that many may abandon broadband service altogether while many others will have to forgo some services or else subscribe to more limited services. The FCC's survey indicates that 29.3% of households would drop the subsidized service and 47.6% would choose a lower-cost service, with 16% left with no service at all.

While broadband adoption has become more equal over the years, in part due to the subsidy programs, some members of Congress are apparently concerned that the reduction in inequality is not worth the cost, which is about $9 billion annually. Those costs could be reduced, perhaps, by altering the qualifications for the program or restricting subsidies to certain types of services. While it seems impossible to limit subsidies to those households without broadband, limiting subsidies to services that are unattractive to households with a strong demand for broadband, thus attenuating substitution to subsidized plans (a separating equilibrium), is a sensible policy option.[17]

NOTES:

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1 *Measuring the Impact of the ACP: Survey Results*, Federal Communications Commission (available at: https://www.fcc.gov/acp-survey; https://www.fcc.gov/sites/default/files/ACP-Survey-Results.pdf).

2 Infrastructure Investment and Jobs Act, Pub. L. No. 117-58, 135 Stat. 429 (2021) (codified at 47 U.S.C. § 1754) ("IIJA").

3 G.S. Ford, *A Fresh Look at the Lifeline Program,* PHOENIX CENTER POLICY PAPER NO. 55 (July 2019) (available at: https://phoenix-center.org/pcpp/PCPP55Final.pdf).

4 E. Dau, *Million to Lose Affordable Internet Unless Congress Extends Subsidies*, THE WASHINGTON POST (January 9, 2024) (available at: https://www.washingtonpost.com/technology/2024/01/09/affordable-connectivity-program-congress).

5 A recent report by John Horrigan of the Benton Institute offers an argument for defunding the ACP. The report claims that a broadband connection increases household income by $187 per month [= $2,200/12], while a broadband subscription averages around $50 per month. Thus, the additional income is more than adequate to fund a broadband subscription (a 200% return). Yet, the income effect of broadband adoption used by Horrigan seems implausible and is likely a spurious result; it is difficult to separate the effects of income-on-adoption and adoption-on-income. J. Horrigan, *The Affordable Connectivity Program Creates Benefits that Far Outweigh the Program's Costs*, Benton Institute for Broadband & Society (2024) (available at: https://www.benton.org/sites/default/files/ACP-Cost-Benefit_0.pdf). On broadband pricing, *see* A. Menko, *2023 Broadband Pricing Index: Broadband Prices Continue to Decline*, USTelecom (2023) (available at: https://ustelecom.org/wp-content/uploads/2023/10/USTelecom-2023-BPI-Report-final.pdf).

6 *AT&T Launches Its Own $10 Internet Access Program for Low-Income Households*, CONSUMERIST: CONSUMER REPORTS (April 22, 2016) (available at: https://www.consumerreports.org/consumerist/att-launches-its-own-10-internet-access-program-for-low-income-households).

7 G.S. Ford, *Will Digital Discrimination Policies End Discount Plans for Low-Income Consumers?* PHOENIX CENTER POLICY PERSPECTIVE No. 23-04 (November 1, 2023) (available at: http://www.phoenix-center.org/perspectives/Perspective23-04Final.pdf); G.S. Ford and L.J. Spiwak, *Digital Discrimination Under Disparate Impact: A Legal and Economic Analysis*, PHOENIX CENTER POLICY PAPER No. 61 (October 2023) (available at: https://phoenix-center.org/pcpp/PCPP61Final.pdf).This is a classic case of the law of unintended consequences. G.S. Ford, *Antitrust Reform and the Law of Unintended Consequences,* NOTICE & COMMENT – YALE JOURNAL ON REGULATION (January 7, 2022) (available at: https://www.yalejreg.com/nc/antitrust-reform-and-the-law-of-unintended-consequences-by-george-s-ford-phd).

8 IIJA, *supra* n. 2.

9 *In the Matter of Implementing the Infrastructure Investment and Jobs Act: Prevention and Elimination of Digital Discrimination,* FCC 23-100, REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULEMAKING, __ FCC Rcd. __ (rel. November 20, 2023).

10 A.A. Gilroy, *Federal Lifeline Program: Frequently Asked Questions*, Congressional Research Service R44487 (October 19, 2017) (available at: https://sgp.fas.org/crs/misc/R44487.pdf).

11 C. Walker, *Low-income Californians Cite Cost as Significant Barrier, Experts Mourn Loss of ACP*, Broadband Breakfast (January 19, 2024) (available at: https://broadbandbreakfast.com/low-income-californians-cite-cost-as-significant-barrier-experts-mourn-loss-of-acp/); *$3.2 Billion to Help Low-Income Households Access the Internet. Here's How*, Pandemic Oversight (December 2, 2021) (available at: https://www.pandemicoversight.gov/data-interactive-tools/data-stories/32-billion-home-internet); M. García-Escribano, *Low Internet Access Driving Inequality*, IMF Blog (June 29, 2020) (available at: https://www.imf.org/en/Blogs/Articles/2020/06/29/low-internet-access-driving-inequality).

12 Data available at: https://www.census.gov/programs-surveys/acs/data.html.

13 Data available at: https://www.usac.org.

14 The projection is calculated using the predictions from a fractional regression with a Logit link.

NOTES CONTINUED:

[15] *Total Enrolled ACP Subscribers by Service Type*, USAC (last visited March 12, 2024) (available at: https://www.usac.org/about/affordable-connectivity-program/acp-enrollment-and-claims-tracker/additional-acp-data); FCC Survey, *supra* n. 1.

[16] R. Gelles-Watnick, *Americans' Use of Mobile Technology and Home Broadband*, Pew Research (January 31, 2024) ("Those who live in lower-income households are particularly likely to rely on their smartphone to go online. The shares who fall into this category are: 28% of Americans in households earning less than $30,000 per year; 19% of Americans in households earning $30,000 to $69,999 per year; 9% of Americans in households earning $70,000 to $99,999 per year; 4% of Americans in households earning $100,000 or more per year.")

[17] *See, e.g.*, G.S. Ford, *A Fresh Look at the Lifeline Program*, PHOENIX CENTER POLICY PAPER No. 55 (July 2019) (available at: https://phoenix-center.org/pcpp/PCPP55Final.pdf).