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Rural Broadband Connectivity and Access to US Government Farm Support

Atticus Graven and K. Aleks Schaefer

The Coronavirus Food Assistance Program (CFAP) was unique in that it was the first US farm support program that allowed producers to enroll through an online portal rather than in person through a local Farm Service Agency (FSA) office. This research investigates the extent to which broadband connectivity affected access to US government farm support under CFAP. We find that a 1-percentage-point increase in county-level broadband availability is associated with a $2.13 increase in county payments per capita under CFAP. However, this relationship is inherently nonlinear along the rural–urban divide.

Key words: Coronavirus Food Assistance Program (CFAP), farm subsidies, rural broadband

Introduction

On April 17, 2020, the US federal government created the Coronavirus Food Assistance Program (CFAP) in an effort to mitigate the impacts of the COVID-19 pandemic on agricultural markets (US Department of Agriculture, 2020c). The program was administered over two rounds and ultimately provided $23.7 billion ($10.6 billion under CFAP1 and $13.1 billion under CFAP2) in direct payments to producers of eligible commodities (Giri et al., 2021). As a result of CFAP and other coronavirus aid programs,[1] government payments accounted for nearly 40% of US farm income in 2020 (US Department of Agriculture, 2021a). In addition to the unprecedented size of the disaster relief program, CFAP was also unique in that it was the first farm support program that allowed producers to enroll through an online portal rather than inperson through a local Farm Service Agency (FSA) office (US Department of Agriculture, 2020b). In addition to enrollment access, this online portal, "farmers.gov," also provided support information, including program eligibility criteria, program updates, and farmer decision tools for selecting appropriate programs.

This research investigates the extent to which broadband connectivity affected access to US government farm support under CFAP. The provision of online program information and enrollment options is an important development to reduce the costs of program administration both from the perspective of the government and the farmer (Graven, 2021). However, the move to online program administration can also *limit* access to government support for farmers and ranchers who do not have reliable internet access. For this population, online resources are a poor substitute for face-to-face contact.[2] Equally importantly, when limited program appropriations are offered on a first-come-

Atticus Graven is an independent researcher and K. Aleks Schaefer (aleks.schaefer@okstate.edu) is an assistant professor in the Department of Agricultural Economics at Oklahoma State University.
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[1] Farm operations were also eligible for additional support under the Paycheck Protection Program (PPP) and the Economic Injury and Disaster Loans (EIDL). Assistance to agricultural producers under these programs totalled approximately $11.4 billion (Giri et al., 2021).

[2] For example, extension services largely moved online at the onset of the COVID-19 pandemic due to business closures, limits on public gatherings, and social distancing requirements. The reduction of in-person social networks may limit awareness of government support programs and eligibility criteria.

first-served basis, producers with high-speed internet access may deplete funds before those without internet access can schedule an appointment for in-person enrollment.

We construct a dataset that matches county-level information on per capita CFAP payment receipts with county-level per capita measures of broadband availability and broadband usage in 2020 from the US Federal Communications Commission (FCC) and the Microsoft Corporation. We find that a 1-percentage-point increase in county-level broadband availability is associated with a $2.13 increase in county payments per capita under CFAP. This relationship doubles in magnitude when we account for actual broadband usage levels. However, this relationship is inherently nonlinear along the rural–urban divide. A 1-percentage-point change in connectivity increases government farm support by as much as $20 per capita in the most rural areas.

Our analysis relates to two strands in the agricultural economics literature. The first strand examines the relationship between broadband connectivity and economic returns in the US agricultural sector. Kandilov et al. (2017) estimate the impacts of the USDA's low-cost broadband loan programs on the US agricultural sector. They find that USDA broadband loans increased farm sales, expenditures, and profits in rural counties lying adjacent to metropolitan counties but not in other types of counties. Kandilov and Renkow (2020) extends this research to estimate the returns on investment to this program. LoPiccalo (2020) investigates the relationship between broadband connectivity and US farm productivity. The author finds evidence of crop yield improvements associated with increased internet connectivity. We believe our analysis is an important contribution to the literature on broadband and agricultural returns, given the large share of farm income that is derived from government payments. In fact, even beyond agriculture, broadband connectivity is positively associated with a range of economic outcomes in rural areas (Whitacre, Gallardo, and Strover, 2014; Holt and Jamison, 2009; Koutroumpis, 2009; Kim and Orazem, 2017). The COVID-19 pandemic further highlighted the importance of these relationships (Whitacre, 2021).

The second strand of related literature examines how program design influences the distribution of government farm payments (Key and Roberts, 2007; Belasco and Smith, 2021) and whether and how the distribution of government payments affects income inequality among farm households (Mishra, El-Osta, and Gillespie, 2009). Most recently, Belasco and Smith (2021) show that—as a result of program design—CFAP payments went primarily to large farms. Considering that CFAP was explicitly designed to aid financially (and otherwise) vulnerable farms, this result is counter to the policy's goals. We extend this literature by looking at how technological aspects of program administration and unequal accessibility affect the distribution of farm payments.

Background

The Coronavirus Food Assistance Program (CFAP)

CFAP payments were made across two rounds (CFAP1 and CFAP2). Producers (either a person or legal entity) with an average adjusted gross income (AGI) of less than $900,000 across tax years 2016, 2017, and 2018, or who received 75% or more of their AGI from farming, ranching, or forestry were eligible for CFAP payments (US Department of Agriculture, 2020c). Between CFAP1 and CFAP2, approximately 99% of US farming operations were eligible for payments. Eligible individual producers could receive up to $250,000 for *each* round of CFAP, for a maximum total of $500,000 in direct payments.

The first round of payments (CFAP1) was authorized under the Coronavirus Aid, Relief, and Economic Security (CARES) Act (Public Law 116-136). Appropriations totaled $16 billion, and payments were made to producers who were harmed by a 5% or more price decrease because of loss of demand due to the COVID-19 pandemic. Application to CFAP1 was open for 108 days, from May 26 to September 11, 2020 (Giri et al., 2021).

The second round of payments (CFAP2) was funded entirely by the Commodity Credit Corporation (CCC) with a $13 billion budget. CFAP2 payments were made for crops that faced a 5%

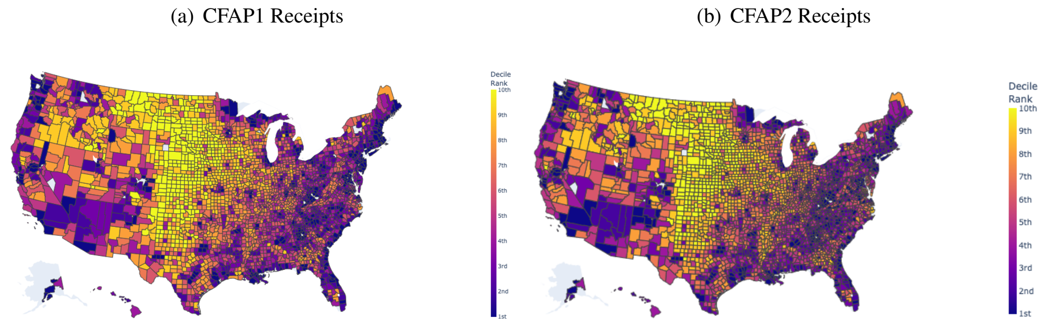

Figure 1. CFAP Payments per Capita through December 2020

Notes: Payments per capita in the above map were broken into deciles to aid visualization. There are a few outliers captured in the bottom and top deciles.

price decrease ("Price Trigger Commodities"). Additionally, CFAP2 paid producers a flat rate for losses on the sale of specialty crops ("Flat Rate" and "Sales Commodities") based on the producers' 2019 sales. Applications for CFAP2 were open for 81 days: September 21 to December 11, 2020 (Giri et al., 2021). In 2021, CFAP2 reopened for about 6 months; our analysis, however, examines only data from the initial application period.

Figure 1 shows county-level receipts per capita under CFAP1 (Figure 1(a)) and CFAP2 (Figure 1(b)). Funds were most intensely distributed to the Midwest, where mostly row crops are grown. Other major agricultural producing regions, including the Central Valley in California and the Hudson Valley in New York, also received substantial CFAP payments. Some politicians and stakeholders criticized CFAP1 because the defined list of "eligible commodities" disproportionately benefited counties that voted for the GOP government (*The Fence Post*, 2020). Partly in response to that criticism, CFAP2 increased the list of eligible products. However, comparing panels (a) and (b) of Figure 1, it is clear that county-level payouts were similar across the two payment rounds.

US Broadband Connectivity

The US Federal Communications Commission (FCC) defines "broadband-speed" internet connectivity as a download speed of at least 25 megabits per second (Mbps) and an upload speed of at least 4 Mbps. This benchmark represents the minimum speed at which a user can "originate and receive high-quality voice, data, graphics, and video services," and is deemed by Congress as necessary to participate in modern life on the internet (US Federal Communications Commission, 2015). Of course, "access" to broadband speed is not straightforward to measure. The FCC regularly measures the percentage of Americans for whom broadband-speed internet is available via a survey of broadband providers known as Form 477. Specifically, the FCC asks broadband providers to enumerate the census blocks within which the provider *could* provide broadband-speed internet (US Federal Communications Commission, 2020).[3] 2(a) shows the percentage of households in every US county for whom broadband was available in 2020. According to the FCC, the mean US county lacked broadband speeds for 24% of residents.

However, the true extent of the broadband problem is likely greater. Whereas the FCC asks providers about who *could* access broadband, Microsoft recently released data showing the percentage of each county's population that actually *achieved* broadband speed in 2020. Microsoft assembled this dataset by measuring the size of and time taken by each download requested from any

[3] Even more specifically, the FCC defines "availability" for the purposes of Form 477 as follows: "Fixed broadband connections are available in a census block if the provider does, or could, within a service interval that is typical for that type of connection—that is, without an extraordinary commitment of resources—provision two-way data transmission to and from the Internet with advertised speeds exceeding 200/kbps in at least one direction to end-user premises in the census block."

(a) Broadband Availability (FCC) (b) Broadband Usage (Microsoft)

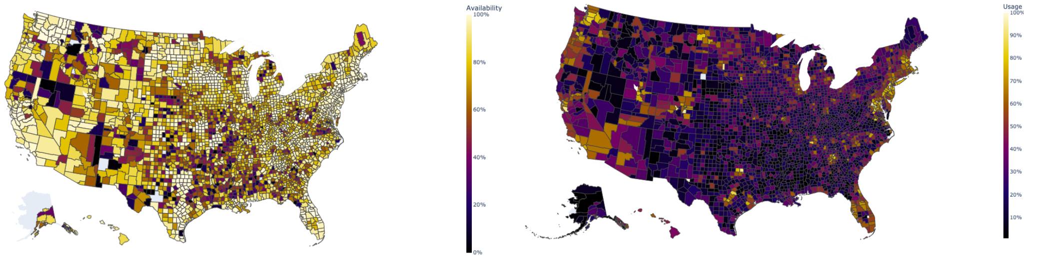

Figure 2. Percentage of Each US County with Access to "Broadband-Speed" Internet

Notes: Brighter-colored counties on the map above indicate a larger percentage of the population with access to broadband-speed internet.

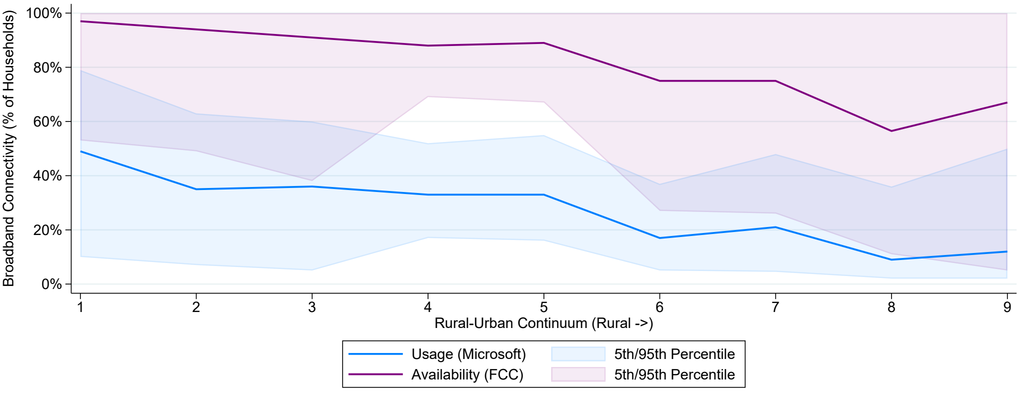

Figure 3. Broadband Connectivity across the Rural–Urban Continuum

Notes: Figure plots the share of households with broadband connectivity (alternatively as defined by the FCC and Microsoft) for the median county, as well as the 5th and 95th percentile county, at each point along the rural–urban continuum. A 1 on the rural–urban continuum is a completely urbanized metropolitan area and a 9 is a low-population county with little development.

Microsoft service and used those observations to calculate the requesting device's download speed at that moment (Microsoft, 2020).[4] Microsoft then used a process known as a reverse IP lookup to ascertain the requester's county. The Microsoft broadband usage data are shown in Figure 2(b). According to these data, almost 75% of US households did not use broadband internet in 2020. Further, urban and suburban areas tend to have much better access than rural areas to broadband-speed internet. Figure 3 plots the share of households with broadband connectivity (alternatively as defined by the FCC and Microsoft) for the median county, as well as the 5th and 95th percentile county, at each point along the rural–urban continuum.[5] In the median "urban" county, broadband speeds are available to 97% and used by 49% of households. However, in the median "rural" county, broadband speeds are only available to 67% of households and used by only 12% of households.

[4] It is a limitation that only interactions with Microsoft services are measured by this dataset; however, Microsoft has such a large and cross-cutting suite of services that the authors feel comfortable assuming that the usage of Microsoft services represents a near-random subsample of total internet usage.

[5] As explained below, the rural–urban continuum is a variable created by the ERS and takes integer values between 1 and 9. A 1 on the scale is a completely urbanized metropolitan area and a 9 is a low-population county with little development (US Department of Agriculture, 2021c).

Methodology

To investigate the extent to which broadband connectivity affected access to government farm support under CFAP in 2020, we construct a series of cross-sectional econometric models that match the county-level per capita payment receipts shown in Figure 1 with the county-level per capita broadband availability and usage measures shown in Figure 2, along with various county geographic, sociodemographic, and economic characteristics.

Econometric Model

We specify that—in a given county i—per capita CFAP payments (denoted $CFAP_i$) are a function of various observable and unobservable county characteristics, collectively denoted vector $\mathbf{Z}_i$. We further allow—but do not impose—that broadband connectivity (denoted $Broadband_i$) also affects access to payments. Accordingly, we estimate the following model:

$$CFAP_i = \alpha + \beta Broadband_i + \mathbf{Z}_i{}'\Theta + e_i \tag{1}$$

where dependent variable $CFAP_i$ is alternatively defined as per capita payments under CFAP1, CFAP2, and the entire CFAP program (i.e., CFAP1 + CFAP2) through December 2020. Similarly, $Broadband_i$, our variable of interest, represents the percentage of households within the county with access to broadband-speed internet connectivity. We consider specifications where this is defined alternatively as per capita availability (as reported by the FCC) and per capita usage (as reported by the Microsoft Company).

We include in vector $\mathbf{Z}_i$ a series of variables designed to capture the nature of agriculture and agricultural productivity in county i. These include the total amount of farm acreage (*FarmAcreage*) in the county, the number of farms (*Farms*) in the county, and the average size of a farm (*FarmSize*) in the county from the 2017 Census of Agriculture, and the percentage of the county workforce that is employed in agriculture (*AgEmployment*) from the *Atlas of Rural and Small-Town America* (US Department of Agriculture, 2020a).[6] We also include total land area of the county in square miles (*LandArea*) and county per capita income level (*Income*), also obtained from the ERS *Atlas of Rural and Small-Town America*. Additionally, the "rural-ness" of a county is almost certainly correlated with agricultural output (and, thus, greater CFAP payments) and the availability of broadband. We control for this by including in vector $\mathbf{Z}_i$ the rural–urban continuum code (*Rural-Urban*) for the county. This variable is created by the ERS and takes integer values between 1 and 9. A 1 on the scale is a completely urbanized metropolitan area (e.g., Orange County, CA) and a 9 is a low-population county with little development (e.g., Clay County, AL) (US Department of Agriculture, 2021c).

Additionally, we include in vector $\mathbf{Z}_i$ the percentage of county-level votes in the 2016 presidential election cast for the Republican Party (*GOP*), obtained from Massachusetts Institute of Technology (2021). A large body of academic literature suggests that agricultural disaster payments are—at least in part—politically motivated (Janzen et al., 2023; Garrett, Marsh, and Marshall, 2006; Liu and Kirwan, 2020; Kasdin and Lin, 2015). As discussed previously, similar criticisms of regional favoritism were launched regarding the allocation of CFAP payments (*The Fence Post*, 2020). Finally, we include a series of state-level fixed effects, which take a value of 1 if county i lies within the state and 0 otherwise. These control for unobserved county traits that are correlated at the state level (e.g., regional infrastructure and related policy, macro climate zone, and proximity to ports). Standard errors are clustered at the state level.

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[6] We acknowledge that—even after including these variables—it is effectively impossible to truly control for the nature of agriculture within each county. Recall that CFAP payments were issued for a range of livestock and crop products. Operations for certain producers (e.g., poultry growers) will have very different acreage requirements than others (e.g., corn growers).

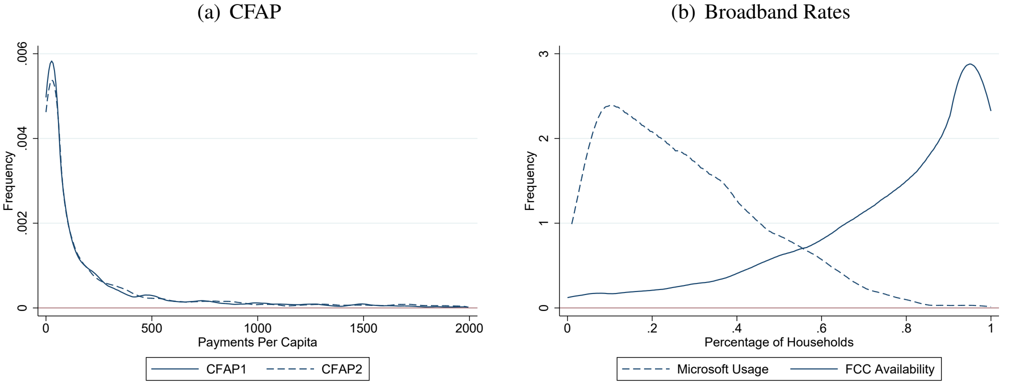


Figure 4. Frequency Distributions for CFAP and Broadband Variables

Notes: Panel (a) shows kernel density estimates for county-level payments per capita under CFAP1 and CFAP2 for the range of payments between $0.05 and $2,000 per capita. For both CFAP1 and CFAP2, this range includes over 95% of observations. Panel (b) plots kernel density estimates for broadband availability and broadband usage rates as a percentage of county households.

Post-Estimation Testing

As discussed previously, both the list of eligible products and the sign-up window were expanded under CFAP2. We hypothesize that these program changes may have affected the relationship between broadband connectivity and county-level program receipts. We test this hypothesis using cross-equation post-estimation tests for the equality of β in the CFAP1 model versus β in the CFAP2 model.

Differences along the Digital Divide

Previous literature has shown that the relationship between broadband connectivity and economic outcomes is inherently nonlinear across urban and rural areas (Aryal et al., 2021; Mann and Loveridge, 2020). Accordingly, we investigate the robustness of our findings to a model that allows coefficient β from equation (1) to differ semi-parametrically across the rural–urban continuum. To do so, we reestimate the model, including the following interaction term:

$$\sum_{j=1}^{9} \beta_j \, Continuum_{j,i} \times Broadband_i \tag{2}$$

where variables $Continuum_{j,i}$ for $j \in [1,9]$ are a series of dummies that take a value of 1 if county i lies at point j along the rural–urban continuum, and 0 otherwise.

Model Robustness

Of course, the relationships between broadband connectivity and CFAP receipts measured in equation (1) are purely correlative, rather than causal. In the appendix, we assess the robustness of the results obtained from estimating equation (1) to three alternative specifications. First, we reestimate equation (1), treating our rural–urban continuum variable (*Rural-Urban*) as a categorical (rather than continuous) variable, where each score along the continuum is assigned its own dummy as in equation (2). Second, the frequency distributions for our CFAP variables (shown in Figure 4) suggest that these variables are left-censored at 0. Accordingly, we reestimate equation (1) using a Tobit model with left-censoring at 0. Finally, we investigate whether the relationship between CFAP payments and broadband is nonlinear, counter to our base specification. To do so, we create five

Table 1. Summary Statistics (*N* = 3,016)

Variable	Description	Mean	Std. Dev.	Min	Max
Dependent Variables					
CFAP	$ per capita	628	1,287	0.00	15,497
CFAP1	$ per capita	287	608	0.00	8,454
CFAP2	$ per capita	341	700	0.00	7,468
Explanatory variables					
Broadband availability	% of households with broadband	0.76	0.24	0.00	1.00
Broadband usage	% of households with broadband	0.27	0.18	0.01	1.00
Control variables					
Income	$ per capita	26,7962	6,118	10,931	69,275
Land area	Square miles	973	1,338	24	20,057
Ag employment	% of workforce (×100)	5.21	6.36	0.00	59.65
Farm acreage	1,000 acres	296	384	0	6,139
Farms	Count of farms	675	541	6	5,551
Farm size	Average acres per farm	663	1,674	1	58,518
Rural–urban	1 = urban, 9 = rural	5.05	2.68	1.00	9.00
GOP	GOP votes in 2016 pres. election (%)	0.64	0.15	0.08	0.95

dummies, which take a value of 1 for each quintile of broadband availability (usage).[7] Results of these three robustness checks are reported in the appendix. The results from these analyses do not change our core findings.

Summary Statistics

Table 1 includes summary statistics.[8] Our final dataset includes observations for 3,016 US counties. On average, total county-level CFAP payments were $628 per capita (standard deviation $1,287), $287 under CFAP1 (standard deviation $608) and $341 under CFAP2 (standard deviation $700). According to the FCC, broadband is available to an average of 76% of residents (standard deviation 24% with a left-skewed distribution) in a given US county. However, according to Microsoft, broadband speeds are used by only 27% of residents (standard deviation 18% with a right-skewed distribution in a given county). Figure 4 shows kernel density estimates for the complete frequency distributions for our *CFAP* and *Broadband* variables.

Results

Table 2 presents the results of estimating equation (1) via OLS. In columns 1–3, we define our *Broadband* variable as Microsoft broadband usage. The dependent variable in columns 1–3 is defined as total CFAP payments, payments under CFAP1, and payments under CFAP2, respectively. In columns 4–6, our *Broadband* variable is FCC broadband availability with the same dependent

[7] In counties in the lowest quintile of broadband availability (usage), 0%–58% of households have access to broadband-speed internet connectivity (0%–10% for usage variable). In counties in the second-lowest quintile of broadband availability (usage), 58%–77% of households have access to broadband-speed internet connectivity (10%–19% for usage variable). In counties in the third quintile of broadband availability, 77%–89% of households have access to broadband-speed internet connectivity (19%–29% for usage variable). In counties in the fourth quintile of broadband availability, 77%–97% of households have access to broadband-speed internet connectivity (29%–43% for usage variable). Counties in which more than 97% (43%) of households have broadband-speed internet connectivity fall into the highest quintile of broadband availability (usage).

[8] Note that—for the purposes of parameter normalization—the *Ag Employment* variable is expressed as a *percentage* of the county workforce, whereas the *GOP* variable is expressed as a *share* of the county voting population.

Table 2. Impacts of County-Level Broadband Usage on CFAP Receipts (OLS)

	Broadband Usage			Broadband Availability		
	CFAP	**CFAP1**	**CFAP2**	**CFAP**	**CFAP1**	**CFAP2**
Variables	**1**	**2**	**3**	**4**	**5**	**6**
Broadband	458.58**	247.09**	211.49**	212.78**	79.51*	133.27***
	(189.34)	(104.85)	(93.17)	(84.11)	(45.96)	(42.06)
Per capita income	0.02***	0.01***	0.01***	0.03***	0.01***	0.01***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Land area	−0.04*	−0.01	−0.03*	−0.04	−0.01	−0.03
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
Ag employment (%)	135.16***	63.32***	71.84***	133.72***	62.48***	71.24***
	(15.09)	(7.77)	(8.43)	(14.48)	(7.46)	(8.18)
Rural–urban continuum	23.81**	8.85*	14.96**	21.60**	6.68	14.92**
	(11.40)	(4.69)	(7.10)	(9.86)	(4.00)	(6.43)
Vote GOP (%)	675.12***	350.40***	324.71***	630.25***	320.83***	309.42***
	(166.19)	(80.40)	(92.07)	(150.56)	(70.68)	(85.53)
Farm acreage	0.16	0.05	0.11	0.13	0.04	0.09
	(0.12)	(0.05)	(0.07)	(0.13)	(0.05)	(0.08)
Farms	−0.03	−0.01	−0.03*	−0.02	−0.00	−0.02
	(0.02)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)
Farm size	−0.02*	−0.00	−0.02***	−0.01	0.00	−0.01***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	3,016	3,016	3,016	2,998	2,998	2,998
R^2	0.76	0.73	0.75	0.76	0.73	0.75
SUR post-estimation test for coefficient equality						
χ^2		1.04			7.01	
p-value		0.31			0.01	

Notes: Values in parentheses are standard errors clustered at the state level. Single, double, and triple asterisks (*, ***, ***) indicate significance at the 10%, 5%, and 1% levels, respectively.

variable specifications as in columns 1–3. We begin by briefly analyzing the behavior of coefficients on our control variables to gauge model validity. Referring across specifications in Table 2, we see that the sign and statistical significance of our control variables are consistent across specifications. First, higher levels of per capita income are associated with higher levels of CFAP payments. This relationship is statistically significant at the 1% level in every specification. A $100 increase in county-level per capita incomes is associated with about $2 in per capita CFAP payments. This is as expected: Higher-income regions are likely to be associated with higher productivity agriculture and, thus, higher CFAP payment receipts. Similarly, the share of the county workforce employed in agriculture (*Ag Employment %*) and the county rural–urban continuum score are both positively correlated with CFAP payments. A 1-percentage-point increase in agricultural employment is associated with approximately $135 in CFAP receipts, and a 1-point increase in "rural-ness" correlates to an additional $22 in payments (both statistically significant at the 5% level).

The political variable (*GOP*) gives perhaps the most surprising control variable relationship. According to column 1 in Table 2, a county where 1% more votes went to the GOP in the 2016 election could be expected to receive almost $7 more in CFAP funding per capita. One explanation of this relationship is that criticisms of political motivation underlying the allocation of CFAP funding are merited, but this is not the only possible explanation. For example, part of this relationship is likely geographic. Although the state dummy variables control for geographic differences in CFAP payments per capita by state, county variation is likely significant, especially in states that have large rural and urban centers that vote differently (e.g., Colorado, California, and Illinois). This relationship could also relate to the structure of the CFAP programs. Some commentators have argued that the structure of CFAP made it easier for bigger, more mechanized farms to apply (Wozniacka, 2020), and big agribusiness tends to overwhelmingly support Republican politicians (*Open Secrets*, 2021).

Referring to the coefficient estimates on *Broadband*—our variable of interest—in Table 2, we see that increased access to broadband-speed internet connectivity is associated with increased CFAP receipts. This result holds both when the *Broadband* variable is defined as actual usage rate and when the variable is defined as FCC availability. Similarly, the relationship is statistically significant at the 5% level when the dependent variable is defined as total per capita CFAP program outlays and as per capita outlays under CFAP1 and CFAP2, separately. According to column 1 of Table 2, every additional 1% of a county population that uses broadband was associated with a \$4.59 increase in CFAP funding per capita. To see the economic significance of this relationship, consider this further example: Holding other factors constant, a county where 50% of the population uses broadband-speed internet could expect to receive \$45.86 more in CFAP payments per capita than a county where only 40% of the population uses broadband-speed internet. That is almost one-third of \$132, which is the median county CFAP payment per capita. Comparing columns 2 and 3, when the *Broadband* variable is defined as actual usage, the marginal effect of broadband connectivity is statistically significantly larger for CFAP1 (\$247.09 ± 129.12) than for CFAP2 (\$211.49±124.91). A possible explanation for this result is that CFAP2 was better publicized, and, therefore, more farm operators who do not use the internet at broadband speed were able to apply. CFAP2 was also open much longer than CFAP1, and the longer window may have allowed less-connected counties to learn of the program and apply.

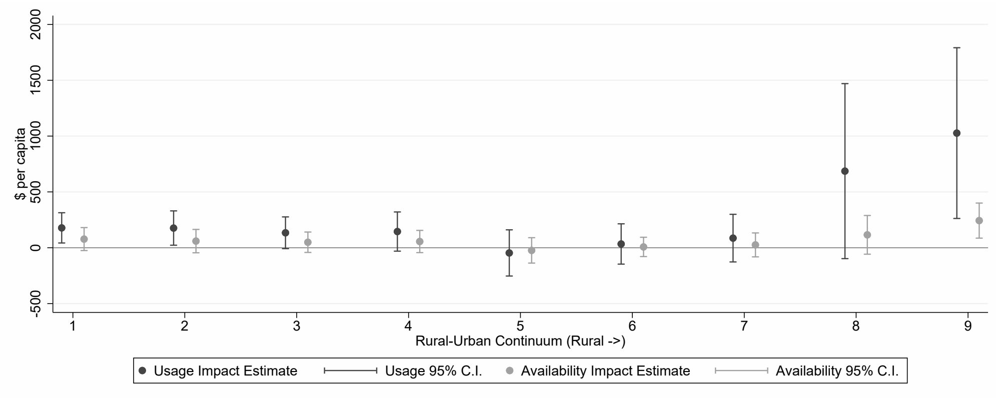
Further comparing the magnitude of the *Broadband* coefficient estimates in columns 1–3 with those in columns 4–6, we see that when the *Broadband* variable is defined as actual usage, the coefficient estimate is statistically significantly larger than when the variable is defined as FCC broadband availability. For example, the coefficient estimate on broadband usage in column 1 is \$458.58±239.49 versus the corresponding FCC availability estimate in column 4 (\$212.78±126.87). This finding also holds when we compare the results in column 2 with those in column 5 and compare the results in column 3 with those in olumn 6. Taken together, these findings suggest that—consistent with previous literature (Whitacre, 2021)—actual usage is a more meaningful measure of the relationship between broadband connectivity and CFAP receipts than broadband availability.

Differences along the Digital Divide

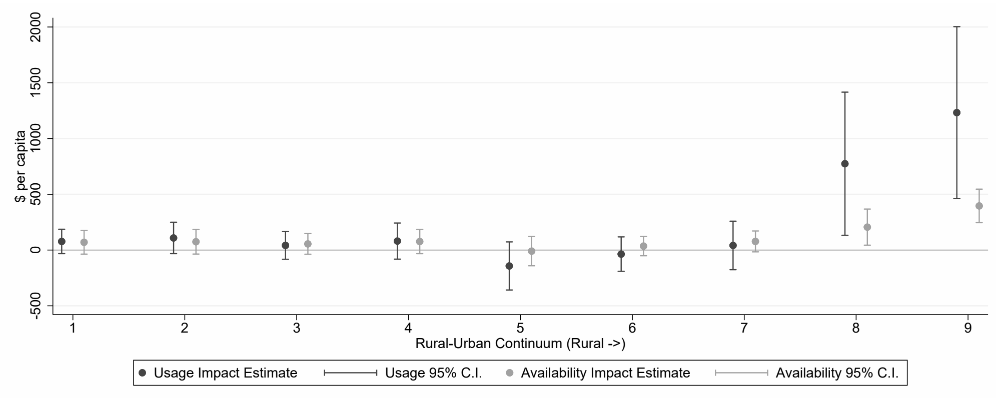
Figure 5 explores whether broadband connectivity affects CFAP payouts differently along the rural–urban divide. The figure reports results of reestimating equation (1), including the interaction terms shown in equation (2) between rural–urban categorical variables and our broadband connectivity variables. Panel (a) reports relationships for CFAP1, panel (b) reports relationships for CFAP2, and panel (c) reports relationships for the total CFAP program.

In Figure 5, the relationship between broadband connectivity and CFAP support was largest in the most rural counties (i.e, those lying at points "8" and "9" on the rural–urban continuum). The direction of this relationship is expected: Many rural counties have major farming operations and are known to have poor internet connectivity. However, the magnitude of the relationship is staggering. Based on a "usage" definition of *Broadband* access, a 1% increase in connectivity increases government farm support by as much as \$20.32 ± 9.04 per capita in the most rural areas under CFAP (panel c), including \$9.58 ± 4.50 under CFAP1 (panel a) and \$10.74 ± 5.03 under CFAP2 (panel b).

(a) CFAP1 Payments per Capita



(b) CFAP2 Payments per Capita



(c) Total CFAP Payments per Capita

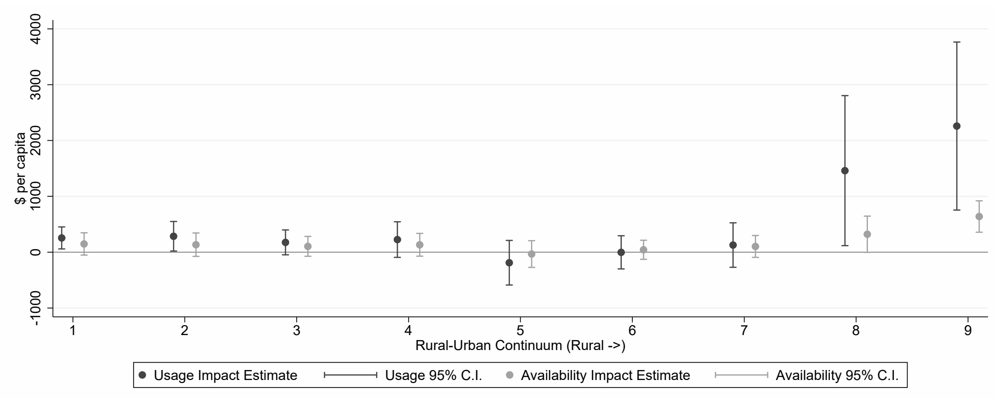


Figure 5. Impacts of Broadband across the Rural–Urban Continuum

Notes: Figure reports results of reestimating equation (1), including the interaction terms shown in equation (2) between rural–urban categorical variables and our broadband connectivity variables.

The results shown in Figure 5 suggest that peri-urban and suburban counties lying in the middle of the rural–urban continuum exhibit small or statistically insignificant relationships between broadband usage and CFAP payments. Yet, perhaps most surprisingly, Figure 5 suggests a statistically significant and economically meaningful relationship between broadband connectivity and CFAP payments in the most urban counties (i.e., those counties falling at points "1" and "2" on the rural–urban continuum). In major urban centers, a 1% increase in broadband usage increases CFAP support by approximately $2 per capita (panel c). We postulate that this may result from affordability rather than mere access or perhaps from the existence of public WiFi deserts in these areas.

Policy Implications and Conclusions

The Coronavirus Food Assistance Program (CFAP) was the first farm support program that allowed producers to enroll through an online portal, rather than in person through a local FSA office. This research investigates the extent to which broadband connectivity affected access to government farm support under CFAP. We construct a dataset that matches county-level information on per capita CFAP payment receipts with county-level per capita measures of broadband availability and broadband usage in 2020 from the US Federal Communications Commission (FCC) and the Microsoft Corporation. We find that a 1-percentage-point increase in county-level broadband availability is associated with a $2.13 increase in county payments per capita under CFAP. This relationship doubles in magnitude when we account for actual broadband usage levels. However, this relationship is inherently nonlinear along the rural–urban divide. A marginal change in connectivity increases government farm support by as much as $20 per capita in the most rural areas.

Our findings are of ongoing policy importance. The FSA has now extended its online enrollment offerings to farm payments administered under the Farm Bill Commodity Title, including Loan Deficiency Payments, Agricultural Risk Coverage and Price Loss Coverage, and the Sugar Program (US Department of Agriculture, 2021b). Poor internet connectivity may lead to unequal access to online enrollment and information services to these programs in the future. On the other hand, Congress has appropriated almost $1.2 billion over the next 2 years to improve high-speed broadband infrastructure in rural areas under the USDA Rural eConnectivity Program (7 CFR 1740). To the extent that these and other infrastructure initiatives lead to increased availability and access to broadband connectivity, the inequities in farm support we study here may be ameliorated.

Of course, our analysis is not without limitations. Perhaps most importantly, because we only have 1 year of data, our estimation is necessarily cross-sectional. Although our findings were robust to a series of alternative model specifications detailed in the appendix, we are unable to strictly determine how changes in broadband connectivity over time influence government farm payment receipts. Second, we are unable to identify the specific mechanism by which broadband affected payments. One could imagine it is, alternatively, access to the online enrollment portal, access to the extension information related to the program, the fact that internet users were able to claim the fixed amount of appropriated funds more quickly, or—most likely—some combination of each of these factors. Finally, several factors—including the contemporaneous COVID-19 pandemic and the short sign-up windows—make CFAP somewhat unique from other government farm support schemes. These particularities may reduce the external validity of our results with respect to future government payment schemes.

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Online Supplement: Rural Broadband Connectivity and Access to US Government Farm Support

Atticus Graven and K. Aleks Schaefer

Model Robustness

As discussed in the methodology section, the relationships between broadband connectivity and CFAP receipts measured in equation (1) are purely correlative, rather than causal. In this appendix, we assess the robustness of the results obtained from estimating equation (1) to three alternative specifications:

- First, we reestimate equation (1), treating our rural–urban continuum variable (*Rural – Urban*) as a categorical (rather than continuous) variable, where each score along the continuum is assigned its own dummy, as in equation (2).
- Second, the frequency distributions for our CFAP variables (shown in Figure 4) suggest that these variables are left-censored at 0. Accordingly, we reestimate equation (1) using a Tobit model with left-censoring at 0.
- Finally, we investigate whether the relationship between CFAP payments and broadband is nonlinear, counter to our base specification. To do so, we create five dummies, which take a value of 1 for each quintile of broadband availability (usage), and 0 otherwise.[1]

Results of these three robustness checks are reported below. Our primary findings are robustness to these analyses.

Categorical Rural–Urban Continuum Variable

Table S1 reports the results of the reestimated model, including dummy variables for each of the codes along the rural–urban continuum. As with the baseline model in Table 2, the results in Table S1 demonstrate a positive and statistically significant relationship between broadband connectivity and CFAP payments. Point estimates in Table 2 are also of similar magnitude to those in Table 2. Referring to columns 1 and 4, we see that a 1-percentage-point increase in broadband availability (usage) increases total CFAP receipts by \$4.59 (\$2.46), respectively, compared to \$4.58 and \$2.13 in the baseline model.

Comparing the coefficients for our variables of interest in Table S1 versus those from our baseline model in Table 2, the biggest change is that the point estimate of the relationship between broadband usage and CFAP1 and CFAP2 payments in columns 5 and 6 increase from \$79.51 and

[1] In counties in the lowest quintile of broadband availability (usage), 0%–58% of households have access to broadband-speed internet connectivity (0%–10% for usage variable). In counties in the second quintile of broadband availability (usage), 58%–77% of households have access to broadband-speed internet connectivity (10%–19% for usage variable). In counties in the third quintile of broadband availability (usage), 77%–89% of households have access to broadband-speed internet connectivity (19%–29% for usage variable). In counties in the fourth quintile of broadband availability (usage), 77%–97% of households have access to broadband-speed internet connectivity (29%–43% for usage variable). Counties in which more than 97% (43%) of households have broadband-speed internet connectivity fall into the highest quintile of broadband availability (usage).

$133.27, respectively, in Table 2 to $94.26 and $152.17 in Table S1. This is consistent with the positive correlation between the rural–urban continuum codes and CFAP payments discussed in reference to Figure 5.

Left-Censored Tobit Model

Table S2 reports the results of estimating equation (1) using a Tobit model with left-censoring at 0, as opposed to ordinary least squares (OLS). Again, referring to the results for our variable of interest (*Broadband*), outcomes are consistent with our base model, with respect to both sign and significance of estimated coefficients. The primary distinction between the Tobit results in Table S2 is that the estimated relationship between broadband and CFAP2 payouts in columns 3 and 6 falls to $205.82 and $132.21 versus estimated coefficients $211.49 and $133.27 from our main model in columns 3 and 6 of Table 2.

Broadband Quintile Analysis

Finally, Figure S1 shows the results of the quintile analysis, where each quintile of broadband availability (usage) is assigned a separate dummy. For the analyses in Figure S1, the dummy for the lowest quintile has been excluded from the model and represents the "baseline" group. These results indicate that the relationship between broadband connectivity and CFAP payouts is, generally speaking, fairly linear across different quintiles of broadband availability (usage).

For example, referring to the relationship between total CFAP payouts and broadband availability in Figure S1(a), we see that moving from the lowest to the second-lowest quintile of broadband availability increases the expected CFAP payout by $2.80 per capita. Moving to the third, fourth, and highest quintile of broadband availability increases expected CFAP payouts by $68.90, $62.22, and $114.45 per capita, respectively. Similarly, referring to the relationship between total CFAP payouts and broadband usage in Figure S1(b), we see that moving from the lowest to the second-lowest quintile of broadband usage increases the expected CFAP payout by $100.42 per capita. Moving to the third, fourth, and highest quintile of broadband usage increases expected CFAP payouts by $100.57, $147.05, and $222.22 per capita, respectively.

Taken together, the results of these three robustness checks indicate that our primary findings are robust to alternative assumptions about the linearity of impact, left-censoring, and the construction of our main control variables.

Table S1. Impacts of County-Level Broadband Usage on CFAP Receipts (OLS robustness)

	Broadband Usage (N = 3,016)			Broadband Availability (N = 2,998)		
	CFAP	**CFAP1**	**CFAP2**	**CFAP**	**CFAP1**	**CFAP2**
Variables	**1**	**2**	**3**	**4**	**5**	**6**
Broadband	459.30**	247.98**	211.31**	246.44***	94.26*	152.17***
	(196.07)	(108.97)	(96.43)	(87.45)	(47.23)	(43.87)
Per capita income	0.02***	0.01***	0.01***	0.02***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Land area	−0.04*	−0.01	−0.03*	−0.03	−0.01	−0.02
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Ag employment (%)	129.60***	60.73***	68.87***	128.02***	59.85***	68.17***
	(14.44)	(7.37)	(8.13)	(13.77)	(7.04)	(7.85)
Vote GOP (%)	680.34***	352.93***	327.41***	639.24***	324.59***	314.65***
	(173.07)	(83.57)	(95.61)	(155.99)	(73.00)	(88.42)
Farm acreage	0.19*	0.07	0.12*	0.17	0.05	0.11
	(0.11)	(0.05)	(0.07)	(0.12)	(0.05)	(0.07)
Farms	−0.03	−0.01	−0.02*	−0.02	0.00	−0.02
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Farm size	−0.03**	−0.01	−0.02***	−0.02**	−0.00	−0.02***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Rural–urban continuum						
2	8.87	−4.50	13.36	−17.03	−17.44	0.41
	(46.94)	(23.75)	(24.49)	(44.23)	(22.80)	(22.92)
3	−19.47	−15.34	−4.13	−31.86	−22.03	−9.83
	(34.59)	(16.15)	(20.16)	(35.41)	(17.17)	(20.01)
4	9.17	−6.46	15.63	−12.51	−16.60	4.09
	(50.16)	(24.90)	(26.72)	(48.46)	(24.24)	(25.88)
5	−129.18**	−73.40***	−55.78*	−148.28***	−81.11***	−67.17**
	(52.33)	(23.41)	(30.41)	(50.54)	(23.07)	(29.03)
6	−30.29	−25.89	−4.40	−62.67	−46.52*	−16.15
	(49.65)	(25.73)	(27.87)	(45.03)	(25.21)	(24.41)
7	2.80	−15.51	18.31	−17.12	−29.77	12.65
	(55.93)	(26.02)	(34.54)	(51.89)	(25.55)	(31.81)
8	100.96	28.44	72.52	78.92	6.75	72.17*
	(85.61)	(46.52)	(48.22)	(71.97)	(40.43)	(41.87)
9	343.63***	138.71***	204.92***	333.85***	126.67***	207.18***
	(115.89)	(46.78)	(72.51)	(106.97)	(43.44)	(68.89)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.76	0.73	0.75	0.77	0.74	0.76

Notes: Values in parentheses are standard errors clustered at the state level. Single, double, and triple asterisks (*, ***, ***) indicate significance at the 10%, 5%, and 1% levels, respectively.

Table S2. Impacts of County-Level Broadband Usage on CFAP Receipts (Tobit)

	Broadband Usage (N = 3,016)			Broadband Availability (N = 2,998)		
	CFAP	CFAP1	CFAP2	CFAP	CFAP1	CFAP2
Variables	**1**	**2**	**3**	**4**	**5**	**6**
Broadband	458.58**	247.09**	205.82**	212.78**	79.51*	132.21***
	(187.51)	(103.84)	(92.35)	(83.29)	(45.51)	(41.62)
Per capita income	0.02***	0.01***	0.01***	0.03***	0.01***	0.01***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Land area	−0.04*	−0.01	−0.03*	−0.04	−0.01	−0.03*
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
Ag employment (%)	135.16***	63.32***	71.93***	133.72***	62.48***	71.35***
	(14.94)	(7.70)	(8.33)	(14.34)	(7.39)	(8.08)
Rural–urban continuum	23.81**	8.85*	14.98**	21.60**	6.68*	14.97**
	(11.29)	(4.64)	(7.01)	(9.76)	(3.96)	(6.35)
Vote GOP (%)	675.12***	350.40***	331.77***	630.25***	320.83***	318.16***
	(164.58)	(79.63)	(92.01)	(149.10)	(70.00)	(85.87)
Farm acreage	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Farms	−0.03	−0.01	−0.03*	−0.02	−0.00	−0.02
	(0.02)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)
Farm size	−0.02*	−0.00	−0.02***	−0.01	0.00	−0.01***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Values in parentheses are standard errors clustered at the state level. Single, double, and triple asterisks (*, ***, ***) indicate significance at the 10%, 5%, and 1% levels, respectively.

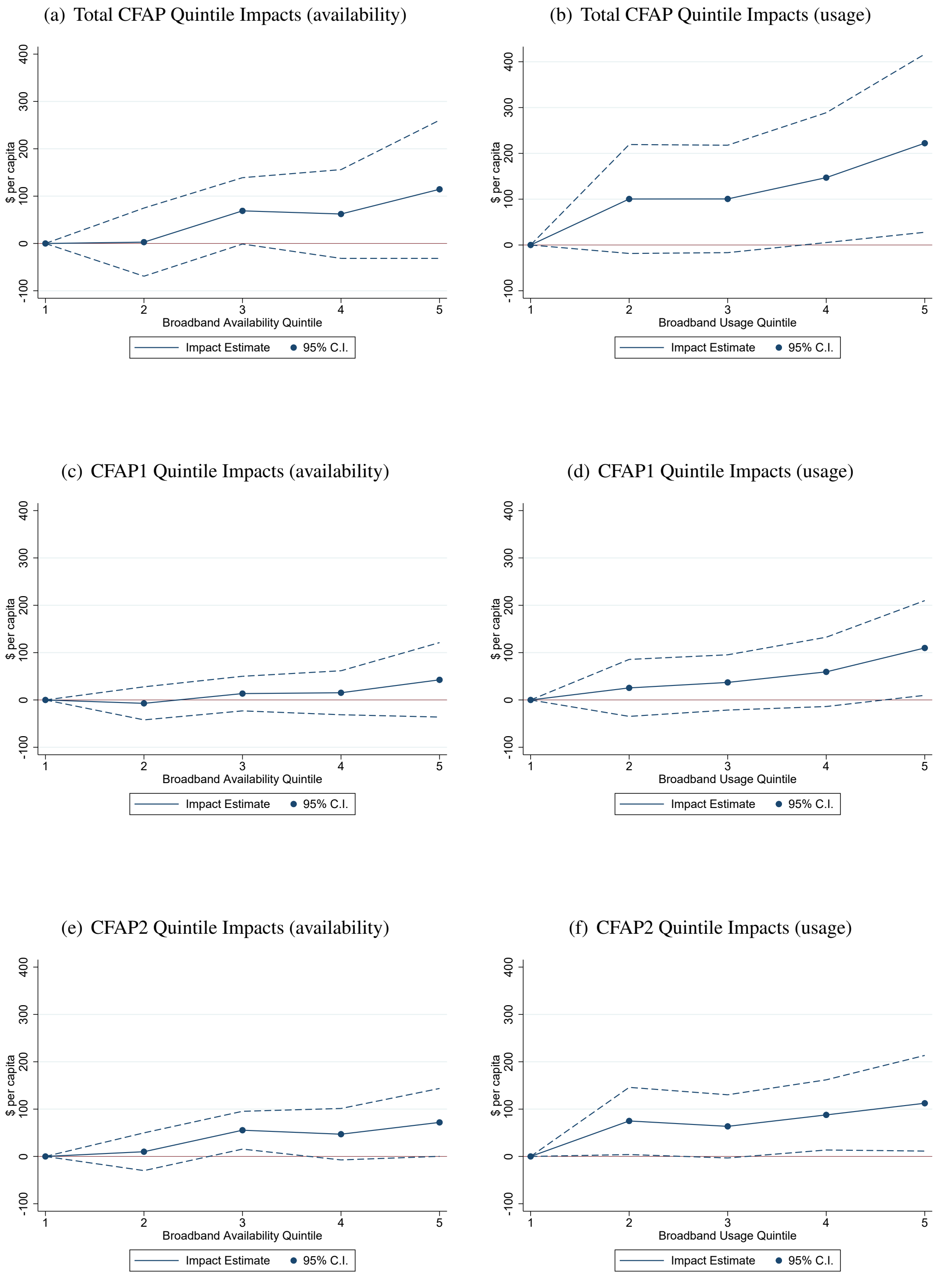

Figure S1. Impacts of Broadband: Quintile Analysis

Notes: Figure reports results of reestimating equation (1), including—instead of a continuous broadband variable—a series of five dummies, which take a value of 1 for each quintile of broadband availability (usage), and 0 otherwise. The dummy for the lowest quintile has been excluded and represents the “baseline” group.