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Impacts of the USDA ReConnect and Community Connect Programs on Broadband Speed in Rural Areas

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Introduction (1)

- COVID-19 pandemic demonstrated critical need for reliable high-speed broadband access for economic, social, & civic life
- A large digital divide between rural and urban America persists
  - In June 2023, 14% of nonmetro population lacked access to fixed terrestrial broadband at advertised speeds of 25 megabits per second (Mbps) download/3 Mbps upload (25/3 Mbps), compared to 3% of metro households (FCC, 2023)
- Federal Government has invested heavily to address the digital divide
  - More than $50 billion invested to promote broadband deployment and adoption prior to 2020
  - $75 billion in new Federal programs approved since the start of the COVID-19 pandemic (GAO, 2022)

Introduction (2)

- Much research has demonstrated benefits of access and adoption of broadband, and recent research demonstrates **impacts of faster speeds** in many contexts:
  - **Higher employment rates** – Briglauer et al. (2019)
  - **Lower unemployment rates** – Lobo et al. (2020)
  - **More business startups** – Deller et al. (2022), Duvivier et al. (2021), Duvivier & Bussiere (2022), Hasbi (2020)
  - **Higher productivity of firms** – Canzian et al. (2019), Fabling & Grimes (2021)
  - **Higher national GDP** – Briglauer & Gugler (2019), Kongaut & Bohlin (2017), Koutroumpis (2019)
  - **Higher county GDP** – Briglauer et al. (2021)
  - **Better educational outcomes** – Grimes & Townsend (2018)
  - **Higher property values** – Ahlfeldt et al. (2017), Deller & Whitacre (2019), Molnar et al. (2019), Klein (2022)

Introduction (3)

- This study investigates impacts on broadband speeds of two USDA broadband programs
  - ReConnect – USDA's largest broadband program – a grant & loan program
  - Community Connect – a much smaller grant only program
- No published studies that we are aware of investigate how any U.S. Federal broadband programs have affected measured broadband speeds
- Few studies investigate impacts of any Federal broadband programs, and none has investigated any impacts of ReConnect
- We find that both programs had a positive impact on broadband speed, though impact of ReConnect cannot be estimated with precision due to a small number of completed projects

Outline of Rest of Presentation

- USDA rural broadband programs
  - ReConnect and Community Connect programs
- Data
- Analytical methods
- Results
- Conclusions
- Possible extensions

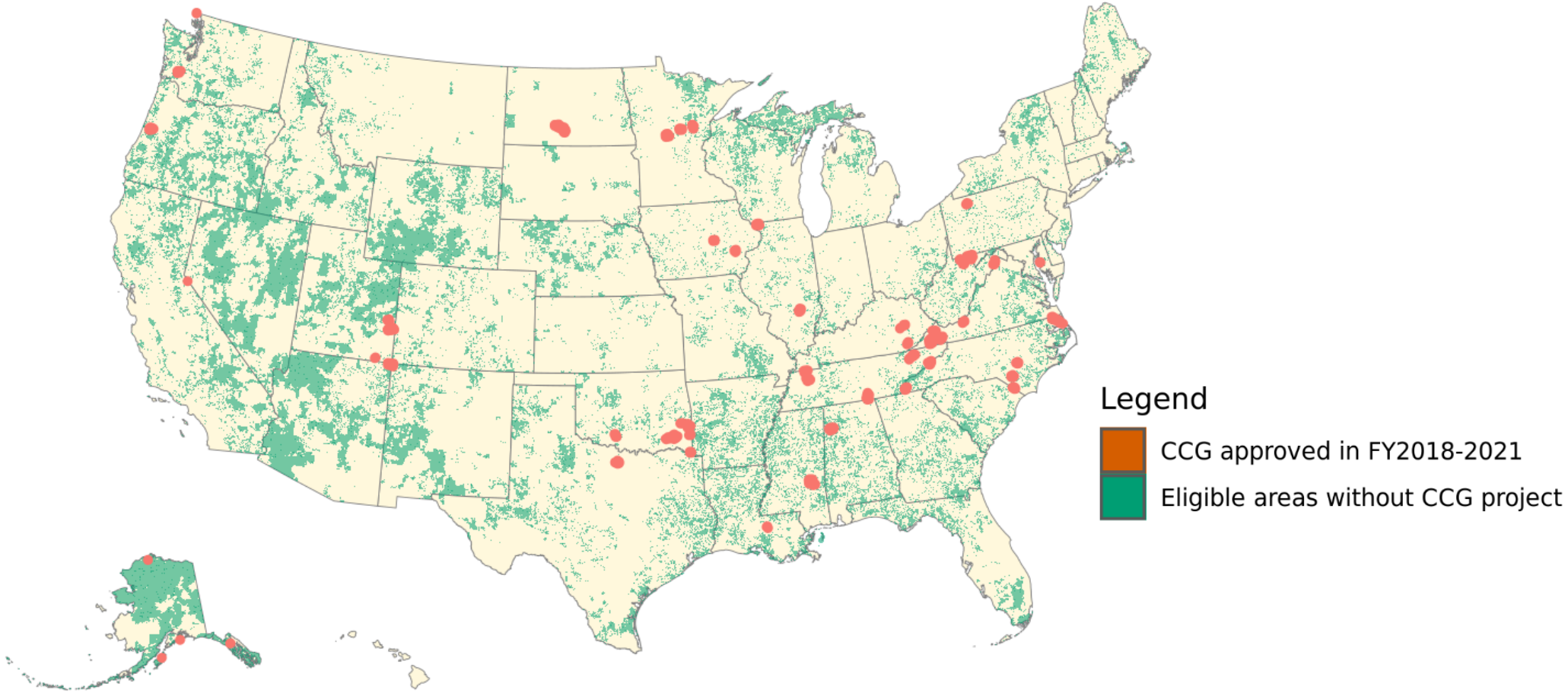
USDA Rural Broadband Programs (1)

- Community Connect and ReConnect are two of five USDA programs that have supported broadband deployment in rural areas. The other three:
  - Telecommunications Infrastructure Loans – continuation of rural telephone loan program established in 1949, has included support of broadband since 1995 (no data available on specific broadband projects)
  - Rural Broadband Access Loans (RBL) – established as a pilot in FY 2001 and became a regular program in FY 2003; few loans since FY 2009
  - Broadband Initiatives Program grants and loans – a large ($2.5 billion appropriation) one-time program established by the American Recovery & Reinvestment Act of 2009; no projects approved after FY 2010

USDA Rural Broadband Programs (2)

- Community Connect (CC) grant program
  - Established as a pilot program in FY 2002 and became a regular program in FY 2004
  - Provides grants to rural areas completely unserved by broadband
  - Annual funding level was $35 million in FY 2023
  - Internet speeds considered unserved have increased, from < 200/200 Kbps in FY 2002-2012 to < 10/1 Mbps in FY 2018, < 25/3 Mbps in FY 2023
  - CC projects were required to achieve at least 25/3 Mbps in FY 2018 and 100/20 Mbps in FY 2023
  - CC supports a variety of broadband technologies; about ¾ of projects approved between FY 2013 and 2021 supported fiber
  - One study estimated impacts of CC grants (as well as RBL loans) on payroll per worker at zip code level through 2007, found statistically insignificant impact of CC grants (Kandilov & Renkow, 2020)

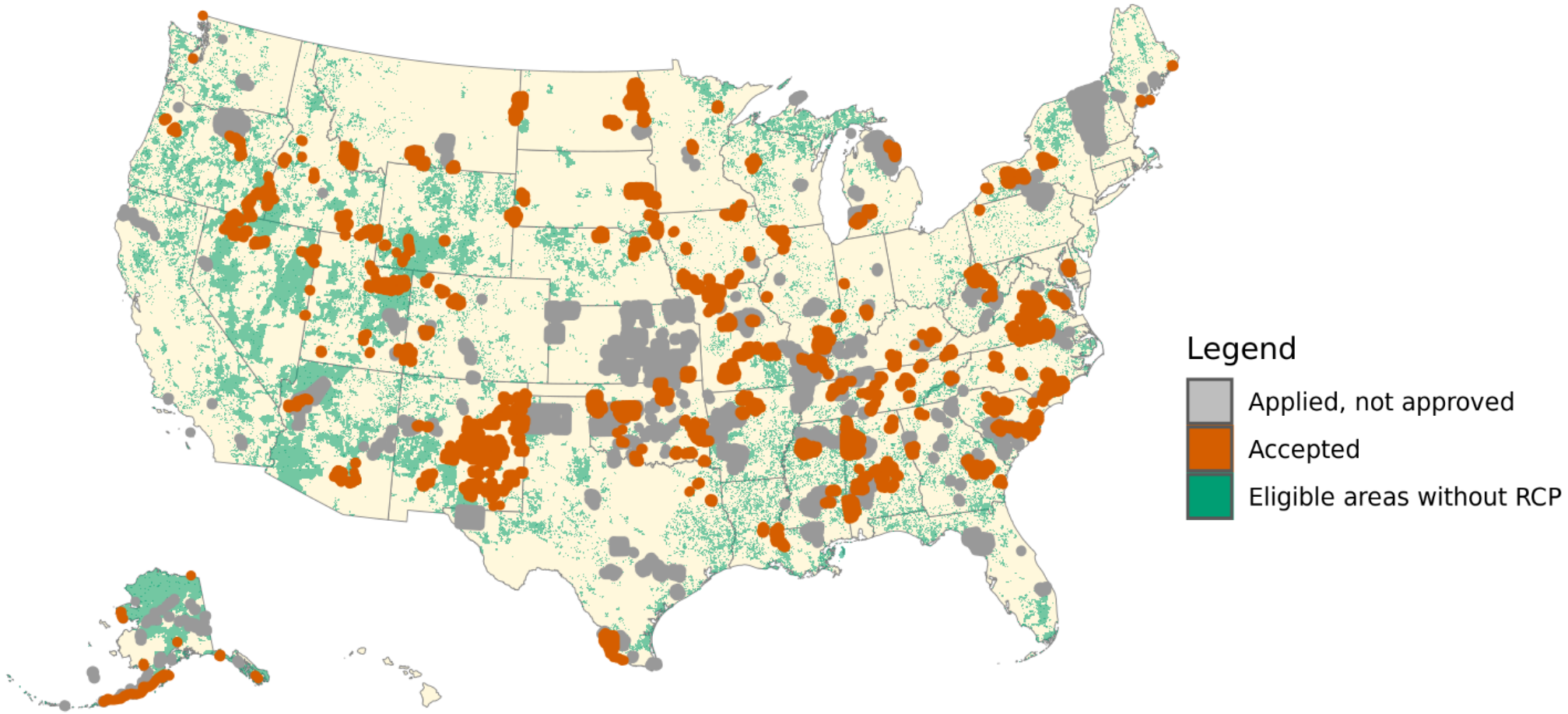
Community Connect – Eligible Areas and Approved Project Areas, FY 2018-2021



USDA Rural Broadband Programs (3)

- ReConnect (RC) grant and loan program
  - Established as a pilot program in FY 2018
  - Provides grants and loans to rural areas unserved or underserved by broadband
  - Largest USDA broadband program, with > $5 billion in appropriations in FY 2018-2023
  - Projects have been approved in four funding rounds so far
  - Internet speeds to be considered unserved have increased, from < 10/1 Mbps in first two funding rounds to < 100/20 Mbps in rounds 3 and 4
  - Projects were required to achieve 25/3 Mbps in rounds 1 and 2, 100/100 Mbps in rounds 3 and 4
  - 97% of projects approved in rounds 1 and 2 supported fiber
  - No published studies have investigated any impacts of ReConnect

ReConnect – Eligible Areas, Applications, and Approved Project Areas, FY 2019-2021



Data

- Program data from Rural Utilities Service (RUS)
  - Approved project service area boundaries and rural areas
  - Project characteristics (grant/loan amount, broadband technology promoted)
  - Date of completion of completed ReConnect projects (by late 2022)
    - 9 completed ReConnect round 1 projects
    - 33 Community Connect projects approved in 2017-2018 (assumed mostly completed by late 2022)
- Ookla Speedtest® data on measured broadband speeds
  - Observed quarterly Q1 2019 – Q4 2022
  - 600 m x 600 m tiles with number of tests + devices, and tile averages upload, download, latency
  - Assessed impacts on mean download speed
- FCC Form 477 data – used to estimate eligible unserved areas
- American Community Survey (ACS) data on census tract demographic and socioeconomic characteristics

Analytical Methods (1)

- Combined Mahalanobis matching to select comparable treated and control census block groups with difference-in-difference (DID) regressions
- Mahalanobis matching
  - Matched census block groups within a project service area (PFSA) (> 75% of area in PFSA) to nearby block groups (within 30 miles); match on ACS socioeconomic and demographic characteristics - median income and home value, unemployment rate, %family households, %poverty, share of black and Hispanic pop.
  - Restricted matches to block groups that were eligible according to program criteria
    - Rural
    - No broadband providers with advertised speed ≥ 10 Mbps download or 1 Mbps upload in December 2017
  - Mahalanobis matching selects matched treated and controls to minimize the metric:

$$\delta(\boldsymbol{x}_i, \boldsymbol{x}_j) = \sqrt{(\boldsymbol{x}_i - \boldsymbol{x}_j)' S^{-1} (\boldsymbol{x}_i - \boldsymbol{x}_j)}$$

where x_i and x_j are vectors of covariates for treated and potential control observations and S is the pooled (across treated and controls) covariance matrix

Analytical Methods (2)

- DID regression specification:

$$log(d_{it}) = \alpha_0 + \alpha_1 \text{PFSA}_i + \sum_{t=1} \beta_t \times \text{Period}_t +$$

$$\sum_{t=1} \gamma_t \text{PFSA}_i \times \text{Period}_t + \delta X_{it} + \theta Y_{p(i)t} + \epsilon_{it}$$

where

- i indexes the block group, t the time-period
- $log(d_{it})$ – natural logarithm of the mean download speed
- $PFSA_i$ – treatment indicator, equals 1 if the block group within a PFSA, 0 otherwise
- $Period_t$ – time period effects; eight 6-month intervals from Q1 2019 to Q4 2022
- X_{it} – tract-level socioeconomic and demographic characteristics from ACS
- $Y_{p(i)t}$ – program characteristics (broadband technology and award size) of p(i), the PFSA associated with block group i

Block Group Level DID Results - ReConnect

- Results based on 9 completed ReConnect projects and 14 block groups. The reference period is 2019 Jan.-June
- Standard errors are high due to insufficient program data; weak evidence of increase in speeds starting in 2021
- The coefficient of 0.5 in July-Dec. 2021 corresponds to an impact of $e^{0.5} \approx 65\%$ increase in download speeds compared to the control group
- Estimated impacts in 2021-2022 range between 28% and 65%, but not statistically significant at 5% level

Variable	Coefficient	Std. Error	% Impact
PFSA	-0.37	0.22	
PFSA x 2019 Jul-Dec	0.00	0.30	0%
PFSA x 2020 Jan-Jun	0.11	0.30	+12%
PFSA x 2020 Jul-Dec	-0.12	0.30	-11%
PFSA x 2021 Jan-Jun	0.25	0.30	+28%
PFSA x 2021 Jul-Dec	0.50*	0.30	+65%
PFSA x 2022 Jan-Jun	0.25	0.30	+28%
PFSA x 2022 Jul-Dec	0.35	0.30	+42%

* indicates statistically significant at 10% level.

Block Group Level DID Results – Community Connect

- Results based on 33 Community Connect projects and 116 block groups
- With a larger sample we estimate a measurable increase in download speeds by early 2021
- Impacts during 2021-2022 range between +26% and +35%

Variable	Coefficient	Std. Error	% Impact
PFSA	-0.05	0.19	
PFSA x 2019 Jul-Dec	0.02	0.09	+2%
PFSA x 2020 Jan-Jun	0.04	0.09	+4%
PFSA x 2020 Jul-Dec	0.10	0.09	+11%
PFSA x 2021 Jan-Jun	0.25***	0.09	+28%
PFSA x 2021 Jul-Dec	0.23**	0.09	+26%
PFSA x 2022 Jan-Jun	0.30***	0.09	+35%
PFSA x 2022 Jul-Dec	0.26***	0.09	+30%

, * indicate statistically significant at 5% and 1% levels, respectively.

Block-Group Level DID Results – Community Connect, Award Size > $10,000/household

- When we consider the 10 Community Connect projects with the largest award size per household served (n=37 block groups), the increase in broadband speeds is more pronounced
- Estimated impacts from late 2020 to late 2022 range from 39% (not stat. sign.) to 93% (stat. sign.)

Variable	Coefficient	Std. Error	% Impact
PFSA	0.03	0.19	
PFSA x 2019 Jul-Dec	0.12	0.21	+13%
PFSA x 2020 Jan-Jun	0.10	0.21	+11%
PFSA x 2020 Jul-Dec	0.41**	0.21	+51%
PFSA x 2021 Jan-Jun	0.66***	0.21	+93%
PFSA x 2021 Jul-Dec	0.33	0.21	+39%
PFSA x 2022 Jan-Jun	0.53**	0.21	+70%
PFSA x 2022 Jul-Dec	0.50**	0.21	+65%

, * indicate statistically significant at 5% and 1% levels, respectively.

Tile-Level DID Heckman Sample Selection Correction

- Selection issue: Many Ookla “tiles” lack observations of broadband speed, and these data likely not missing at random
- Stage 1: Probit model for presence/absence of observation in tile *i* during period *t:*

$$\text{Probit}(\eta_{it}) = \alpha_0 + \alpha_1 \text{PFSA}_i + \sum_{t=1} \beta_t \times \text{Period}_t + \sum_{t=1} \gamma_t \text{PFSA}_i \times \text{Period}_t + \delta X_{it} + \epsilon_{it}$$

- Stage 2: Compute the inverse Mills ratio (IMR) and use as a covariate in the difference in difference model for observed tiles:

$$log(d_{it}) = \zeta_0 + \zeta_1 \text{PFSA}_i + \sum_{t=1} \theta_t \times \text{Period}_t + \sum_{t=1} \kappa_t \text{PFSA}_i \times \text{Period}_t + \rho \text{IMR}_{it} + \epsilon_{it}$$

DID Results – Community Connect with Heckman Correction – Tile-Level Analysis

- Results based on 33 Community Connect projects and 14,067 tiles with observed download speeds
- Impacts during 2020-2022 range between +58% and +151%
- Sample selection biased downward the impact estimates. Without Heckman correction, impacts beginning July-Dec. 2020 range between +36% and +70%

Variable	Coefficient	Std. Error	% Impact
PFSA	-0.42***	0.09	
PFSA x 2019 Jul-Dec	0.16	0.11	+17%
PFSA x 2020 Jan-Jun	0.46***	0.11	+58%
PFSA x 2020 Jul-Dec	0.62***	0.11	+86%
PFSA x 2021 Jan-Jun	0.73***	0.11	+108%
PFSA x 2021 Jul-Dec	0.86***	0.12	+136%
PFSA x 2022 Jan-Jun	0.92***	0.11	+151%
PFSA x 2022 Jul-Dec	0.84***	0.11	+132%
Inverse Mills ratio	2.72***	0.20	

, * indicate statistically significant at 5% and 1% levels, respectively.

Conclusions

- Both ReConnect and Community Connect projects appear to have increased mean download speeds, though results for ReConnect are statistically weak due to small number of completed projects in our data
- In block group-level analysis of Community Connect impacts without sample selection correction:
  - Community Connect projects approved in FY 2017-18 increased broadband speeds in 2021-2022 by 26% - 35%
  - Community Connect projects that cost more per household had larger impacts on broadband speeds
- In tile-level analysis of Community Connect impacts with sample selection correction:
  - Community Connect projects increased broadband speeds in 2020-2022 by 58% - 151%

Possible Extensions

- Include additional years of data on completed ReConnect projects
- Estimate economic benefits of these programs; how are these increases in broadband speed capitalized into property values?
- Investigate heterogeneity of impacts and economic benefits

References (1)

Ahlfeldt, G., Koutroumpis, P. & Valletti, T. (2017). Speed 2.0: Evaluating access to universal digital highways. *Journal of the European Economic Association* 15(3), 586-625.

Briglauer, W., Dürr, N. S., Falck, O., & Hüschelrath, K. (2019). Does state aid for broadband deployment in rural areas close the digital and economic divide? *Information Economics and Policy*, *46*, 68-85.

Briglauer, W., Dürr, N., & Gugler, K. (2021). A retrospective study on the regional benefits and spillover effects of high-speed broadband networks: Evidence from German counties. *International Journal of Industrial Organization*, 74(January), 102677. doi: 10.1016/j.ijindorg.2020.102677

Briglauer, W., & Gugler, K. P. (2019). Go for gigabit? First evidence on economic benefits of (ultra-)fast broadband technologies in Europe. *Journal of Common Market Studies, 57*(5), 1071-1090.

Canzian, G., Poy, S., & Schüller, S. (2019). Broadband upgrade and firm performance in rural areas: Quasi-experimental evidence. *Regional Science and Urban Economics*, *77*, 87-103.

Deller, S., & Whitacre, B. (2019). Broadband's relationship to rural housing values. *Papers in Regional Science* 98(5), 2135-2156.

Deller, S., Whitacre, B., & Conroy, T. (2022). Rural broadband speeds and business startup rates. *American Journal of Agricultural Economics*, *104*(3), 999-1025.

Duvivier, C., & Bussière, C. (2022). The contingent nature of broadband as an engine for business startups in rural areas. *Journal of Regional Science*, *62*(5), 1329-1357. https://doi.org/10.1111/jors.12605

Duvivier, C., Cazou, E., Truchet-Aznar, S., Brunelle, C., & Dubé, J. (2021). When, where, and for what industries does broadband foster establishment births?. *Papers in Regional Science*, *100*(6), 1377-1401. https://doi.org/10.1111/pirs.12626

References (2)

Fabling, R., & Grimes, A. (2021). Picking up speed: Does ultrafast broadband increase firm productivity? *Information Economics and Policy, 57*, 100937.

Federal Communications Commission (FCC). (2023). FCC National Broadband Map. https://broadbandmap.fcc.gov/data-download/nationwide-data?version=jun2023.

Grimes, A., & Townsend, W. (2018). Effects of (ultra-fast) fibre broadband on student achievement. *Information Economics and Policy, 44*, 8–15.

Hasbi, M. (2020). Impact of very high-speed broadband on company creation and entrepreneurship: Empirical evidence. *Telecommunications Policy, 44*(3), 101873.

Klein, G.J. (2022). Fiber-broadband-internet and its regional impact — An empirical investigation. *Telecommunications Policy* 46(5), 102331.

Kongaut, C. and Bohlin, E. (2017). Impact of broadband speed on economic outputs: An empirical study of OECD countries. *Economics and Business Review*, *3*(2), pp.12-32. https://doi.org/10.18559/ebr.2017.2.2

Koutroumpis, P. (2019). The economic impact of broadband: Evidence from OECD countries. *Technological Forecasting and Social Change*, *148*, 119719.

Lobo, B. J., Alam, M. R., & Whitacre, B. E. (2020). Broadband speed and unemployment rates: Data and measurement issues. *Telecommunications Policy*, *44*(1), 101829.

Molnar, G., Savage, S.J., & Sicker., D.C. (2019). High-speed Internet access and housing values. *Applied Economics* 51(55), 5923-5936.

U.S. Government Accountability Office (GAO) (2022). *Broadband: National Strategy Needed to Guide Federal Efforts to Reduce Digital Divide*. GAO-22-104611.