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State broadband policy: Impacts on availability

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ABSTRACT

We use a county-level panel dataset from 2012 to 2018 to assess the impacts of various state policies on total and rural broadband availability in the United States. The primary dependent variable is the percentage of residents with access to 25 Megabits per second (MBPS) download and 3 MBPS upload speeds via a fixed connection, with alternative specifications considering other aspects of availability such as technology type and competition. We control for the main determinants of Internet availability such as income, education, age, and population density. Our policy variables come from the newly released State Broadband Policy Explorer from the Pew Charitable Trusts and individual contacts from the nationwide State Broadband Leaders Network. Our primary policies of interest are those related to: (1) availability of state-level funding, (2) existence of a state-level broadband office/task force with full-time employees, and (3) restrictions on municipal/cooperative broadband provision. We find a positive and significant impact of state-level funding programs on general (and fiber) broadband availability, and a negative impact of municipal/cooperative restrictions. The findings are similar when the analysis is restricted to the rural portions of counties.

1. Introduction

The provision of broadband Internet is an increasingly important topic for today's society. This is particularly true for rural areas that have continued to lag behind their more urban counterparts as broadband technology has diffused (Perrin, 2019; Humphreys, 2019). Recent research has shown that broadband matters for many aspects of rural life, including attracting businesses (Kim & Orazem, 2017), income generation (Whitacre et al., 2014a), and raising farm profits (Kandilov et al., 2017). Broadband connectivity also has the potential to allow rural students to experience a wider variety of educational opportunities, improve the scope of available health care services (Drake et al., 2019), and encourage a broader array of social interaction than is typically available in a small town (Whitacre & Manlove, 2016). Alternatively, rural communities that lack adequate broadband provision will face significant disadvantages in all of these areas. Data from the Federal Communications Commission (FCC) show that the percentage of rural residents with access to the current official definition of broadband has increased from 35% in 2011 to 78% as of 2018. However, state-level variation in the current status of rural broadband is significant: the 2018 availability rate is less than 60% of the rural population in six states but exceeds 90% in nine others (FCC, 2020). Even larger differences exist for county-level rural broadband availability measures.

States have taken many different approaches to improving their rural broadband connectivity. Some states, such as California,

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Florida, and Maine, set up official broadband task forces or state agencies relatively early on (i.e. before 2010) and have relied on these offices to promote rural broadband development. Such offices may have been instrumental in obtaining the significant amount of federal broadband funds distributed by the FCC or the United States Department of Agriculture (USDA); alternatively, they may have worked with private providers in the state to assess local demand and help make a business case for investment. Other states have focused more extensively on right-of-way legislation, including those that have a "dig-once" policy (currently eight including Minnesota, Iowa, and Colorado). Several have mandated their own funding mechanisms, with New York, Massachusetts, and Indiana among a group offering between $20M to $500M grant programs. Other state policies may also factor in, such as the 25 states that currently restrict certain types of organizations – typically electric cooperatives and municipalities – from providing broadband services (Chamberlain, 2019). Despite the importance of such programs and policies to rural America, little research has investigated their impacts on actual broadband provision. This may be because until recently, no comprehensive dataset existed regarding the extent of broadband-related legislation in each state.

This analysis uses a county-level panel dataset from 2012 to 2018 to assess the impacts of various state policies on the availability of broadband. The primary dependent variable is the percentage of county residents with access to 25 megabits per second (Mbps) download/3 Mbps upload speeds (the current FCC threshold) via a fixed connection, excluding satellite. Alternative specifications consider other important aspects of availability, such as technology type and competition. Our policy variables come from a combination of: (1) the newly-released State Broadband Policy Explorer from the Pew Charitable Trusts and (2) personal contacts from the national State Broadband Leaders Network (SBLN). The SBLN is a consortium of practitioners across various agencies working on state broadband initiatives, whose members typically have institutional knowledge about historical broadband efforts in their respective states. Our primary policies of interest are those related to: (1) availability of state-level funding, (2) existence of state-level broadband offices with full-time employees, and (3) legislative restrictions on municipal/cooperative broadband efforts. Arguments have been made for and against such policies (Siefer, 2015; Lichtenberg, 2017; Sallet, 2020; Park, 2020); although mostly (as we note below) without thorough empirical evidence. We first employ simple descriptive statistics and visual tools (i.e. showing deployment trends for counties with/without specific policies) and build to more complex dynamic panel regressions that can single out the impact of specific policies on broadband availability. These regressions control for confounding factors such as local education, income, and housing characteristics, while also recognizing that the dependent variable (availability) depends on its own past realizations.

The results suggest that state-level policies have gotten more popular over time, and that they matter for increasing broadband availability. The visual tools show that availability rates have generally trended up over time regardless of the local policy environment; in only a few cases do we appear to see divergence after a policy is enacted. The regression results, however, demonstrate a consistently positive impact of state broadband funding on availability, and show that the existence of municipal broadband restrictions tends to lower availability and broadband competition. The policy results are slightly stronger when the analysis is restricted to only rural portions of counties.

2. Background

Rural broadband continues to be a hot topic in today's political arena. President Trump has issued several orders directing funding towards rural broadband (Rachfal & Gilroy, 2019) and each of the leading Democratic presidential candidates included proposals for significant rural broadband spending as part of their platforms (Craft, 2020). These positions are well founded: 24% of rural residents say that broadband access is a major problem in their community (Anderson, 2018), and academic research on the topic increasingly demonstrates that broadband availability and adoption matters for social and economic outcomes in rural areas. The recent COVID-19 pandemic has made clear the importance of broadband access for all members of society (Kimmelman, 2020; Levin, 2020).

The amount of literature focused explicitly on *rural* broadband has grown dramatically over the past decade. Several papers have found that broadband availability is an important factor for rural business location choices (Kim & Orazem, 2017; Mack, 2014), and others have documented its positive impact on rural in-migration rates (Mahasuweerachai et al., 2010) and housing values (Deller & Whitacre, 2019). COVID-19 has brought the rural broadband issue to the forefront of the policy environment for a variety of institutions (Cullen, 2020; Giorgi, 2020).

One of the largest federal programs focused on rural broadband availability, the USDA's broadband loan program, has been thoroughly evaluated. The results generally show positive returns from the funds distributed under this program, including for the impacts it has on local farmers (Kandilov et al., 2017); on local broadband provision (Dinterman & Renkow, 2017); and on the overall rate of return (Kandilov & Renkow, 2019). Other federal programs seeking to address rural broadband were the $7.2B allocated during the American Recovery Reinvestment Act (ARRA) in 2009 and the $400M awarded by the Federal Communications Commission's Connect America Fund (CAF) in 2012 and 2014. Phase II of the CAF program provided an additional $1.5B in 2018. The USDA broadband loan program awarded nearly $7B between 2009 and 2016 (Kruger, 2019). It is worth noting that these federal programs are typically much larger than any existing state fund. While most studies in this area have focused on simple broadband availability using the existing FCC speed threshold, at least one has looked at the potential impact of faster speeds that are becoming increasingly common: Lobo et al. (2020) find that higher speed broadband rates (>100 Mbps) in rural Tennessee are associated with lower unemployment rates.

However, other studies have argued that it is broadband *adoption* that is more closely correlated with rural economic growth (instead of simple availability). Whitacre et al. (2014a) found that rural counties with high levels of broadband adoption during the 2000s saw higher levels of income growth and lower unemployment than otherwise similar communities with lower adoption. These relationships did not hold true for rural counties with higher levels of availability. Similarly, Whitacre et al. (2014b) documented that increases in broadband adoption were correlated with positive changes in jobs and income in rural counties (after controlling for other potentially influential factors), while increases in availability did not. More recently, Gallardo, Whitacre, Kumar, & Upendram (2020) show that broadband adoption has a stronger relationship with county-level productivity than alternative measures of simple availability.

The distinction between availability and adoption is also made in several other studies. An Amazon-commissioned report argued that better *adoption* of online business tools in rural locations could lead to a potential $47B in gross domestic product (GDP) over the next 3 years (U.S. Chamber Technology Engagement Center, 2019); similarly, a study funded by the web host GoDaddy found that rural counties with more active websites have higher prosperity levels (Mossberger et al., 2020). It is worth noting, however, that trying to improve broadband *adoption* rates is not easy. Two studies evaluating well-known programs focused on increasing local broadband adoption rates found that they had little to no impact (Hauge & Prieger, 2015; Manlove & Whitacre, 2019). This is in direct contrast with the research on *availability*-focused funding that show positive results of such programs (Dinterman & Renkow, 2017). Clearly, however, availability is an important requirement for adoption, and one study found that the reduced levels of availability in rural areas explained about half of the rural-urban broadband adoption gap as of 2013 (Whitacre et al., 2015).

Thus, a significant body of evidence suggests that broadband is important for rural economic growth, and evaluations of federal-level broadband programs have been conducted. The surprising fact is, however, that despite significant differences in availability and adoption across states, a limited number of outdated studies have focused on how *state-level* policy has affected broadband outcomes. One early study concluded that most state-level policies were ineffective when it came to broadband penetration, including policies like universal service mechanisms, tax incentives, and/or laws limiting municipal deployment (Wallsten, 2005). Another early study looked at broadband-related policies in the European Union, South Korea, Japan and the United States. When discussing state-level policies in the United States, it found that the majority of initiatives focused on attracting providers and that the most successful of these implemented initiatives involved promoting demand (Falch, 2007).

However, a newer, more robust look at the role state-level policies affecting broadband access is lacking. The closest effort is Siefer's (2015) compendium of resources and approaches for state-level broadband policy, which lays out elements of good broadband policy but stops short of empirically demonstrating their impacts.[1] To some extent this lack of existing policy-focused research is understandable for the U.S. situation, with no clear source of information about the policies in existence in each state, and a variety of agencies with jurisdiction over broadband. Working through each state's historical legislative statutes on this topic is no small feat, but this is exactly what Pew Charitable Trust's state broadband policy explorer did in July 2019. Their database features heavily in our analytic approach.

One specific policy assessed in our paper – restrictions on municipal broadband provision – has been hotly contested in recent years. Because it involves governmental entities entering a private market, the topic is highly controversial. Proponents argue that this type of provision is necessary in areas with poor or nonexistent service; opponents contend that such networks are publicly-subsidized unfair competition to private providers (Kruger & Gilroy, 2016). Case studies of existing public broadband networks point to a lack of responsiveness by incumbent providers as rationale for the original investment (Tanner et al., 2018; Whitacre et al., 2007). Some research has shown that municipally-owned providers typically offer lower-priced packages (Talbot et al., 2017) while other work has questioned whether such networks are economically viable over the long term (Yoo & Pfenninger, 2018).

From an international perspective, several papers have explored the impact of policies on broadband penetration. The most recent (and most related to our work) is Ghosh's (2017) research on the existence of National Broadband Plans for 15 Middle East, North Africa, Afghanistan (MENA) countries during the period 2001–2014. Ghosh finds a positive and statistically significant impact of a national broadband plan on fixed broadband penetration; however the results were driven by countries with relatively higher levels of access. In countries with lower fixed broadband penetration, plans were not shown to have any statistical influence. It is worth noting that this analysis did not break national broadband plans down into any specific components; rather the simple presence of a plan was assessed across the panel. Earlier work focused on the importance of regulatory independence for Latin American/Caribbean countries (Montoya & Trillas, 2011). Gulati and Yates (2012) use data from 148 countries as of 2008 and found that a competitive telecommunications sector was strongly linked to greater broadband penetration, but that having a national regulatory authority had a negative impact. The existence of strong competition among different broadband technologies was also emphasized by Cava-Ferreruela and Alabau-Munoz (2006), who reviewed 30 OECD countries over the period 2000–2002, and Bouckaert et al. (2010), who assessed 20 OECD countries during 2003–2008. More recently, Abrardi and Cambini (2019) lament the scant empirical evidence related to how different regulatory approaches impact ultra-fast broadband network deployment, and also review the theoretical literature suggesting that regulatory policies could, in fact, matter.

Generally, then, the existing literature does not speak to the effectiveness of sub-categories of broadband policy from a U.S. perspective: do states that have active broadband funding mechanisms fare better than those without? Do regulations limiting the existence of municipal or cooperative broadband efforts limit overall availability, or the percentage of the population with access to fiber? How important is the presence of a state broadband office in encouraging competition? We seek to answer these questions using the data and methodology laid out in the following section.

[1] It is worth noting that three of Siefer's (2015) "Elements of Good Broadband Policy" include (1) a dedicated office at the state level, (2) direct funding of broadband development, and (3) promoting local partnerships – all related to the main policies we assess in this paper.

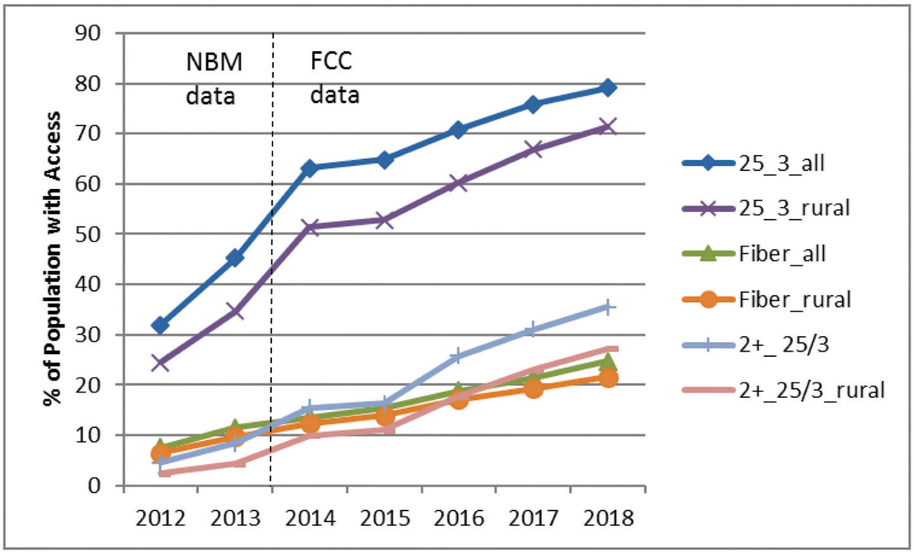

Fig. 1. Broadband availability averages for U.S. Counties, 2012–2108.
Source: FCC Form 477 data, 2012–2018 (author's calculations).

3. Data and methods

3.1. Broadband availability

Our broadband availability data come from the census-block-level entries underlying the December versions of the National Broadband Map (NBM, 2010–2013) and the current FCC Broadband Deployment Map (2014–2018). The benefit of using this low level of geography is twofold. First, it allows us to construct both overall and rural-only availability measures for each state and county.[2] Second, being able to aggregate from the most granular level available (e.g. census blocks) ensures the broadband related metrics are not "watered down" by utilizing higher order geographies (e.g. census tracts or counties). For example, a broadband metric calculated at the county-level masks underlying variances that only become apparent when a researcher delves down into a lower level of geographic detail. In fact, this is one of the major issues of the FCC data itself where one household with access within the census block labels the entire block as served, overlooking other households within the census block without access. Such an impact is magnified when counties are used as the starting point of analysis. We capture the lowest level of broadband variation available before aggregating to the more workable county level.

We acknowledge that the FCC and NBM data have faced a significant amount of criticism – including by members of Congress (Ford, 2011; Grubesic & Mack, 2016; Taglang, 2020). These include that the data capture advertised (as opposed to actual) speeds, that providers submitting the data have misreported, and the assumption of full census block service noted above. This last issue is arguably the most serious, and recent research has demonstrated that the FCC broadband data may overstate availability by as much as 20 percent, with larger bias in more rural states (Busby & Tanberk, 2020). These data issues are a limitation of our analysis, and we discuss them further in our conclusion. Nonetheless, the NBM and FCC data remain the most detailed and consistent broadband availability datasets in existence.

Our compilation is done using FCC population estimates for each block, which are provided on an annual basis. The "rural-only" measures use the 2010 census "rural" classification for each block. We restrict our analysis to the period 2012–2018 given that the early iterations of the NBM, which was compiled by a different entity in each state, had low response rates from local providers when the data gathering process was first rolled out. Each version of the dataset collected information on the maximum advertised speed available to each block (both download and upload), the technology used (i.e. cable vs. fiber vs. digital subscriber line (DSL)), and the number of unique providers offering service.

We gather several availability measures, including the percentage of population with access to specific speeds (the current 25 Mbps down/3 Mbps up; and the earlier FCC threshold of 10 Mbps down, 1 Mbps up),[3] with access to fiber technology,[4] and with at least 2 providers advertising 25/3 speeds. Each of these is compiled at the county level, giving us a total of 3140 observations across 7 years. Fig. 1 displays the annual averages for these 3 primary measures for 1) all population and 2) rural-only population.

[2] The U.S. Census Bureau defines "rural" areas as those outside of urban clusters of 2500 people or more.

[3] The NBM gathered speed data in categories as opposed to the continuous measures used by the FCC map. 2012, in particular, only captured upload speeds of 1.5 Mbps and as such is not perfectly comparable to other years.

[4] Fiber is largely recognized as the premier type of broadband technology due to its nearly unlimited bandwidth and low latency (Cyphers, 2019).

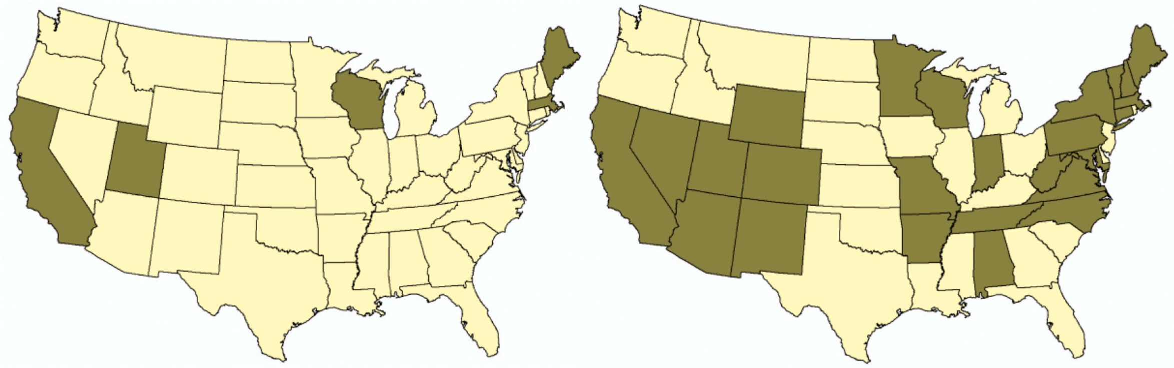

Fig. 2. State broadband offices, 2012 (left) and 2018 (right).

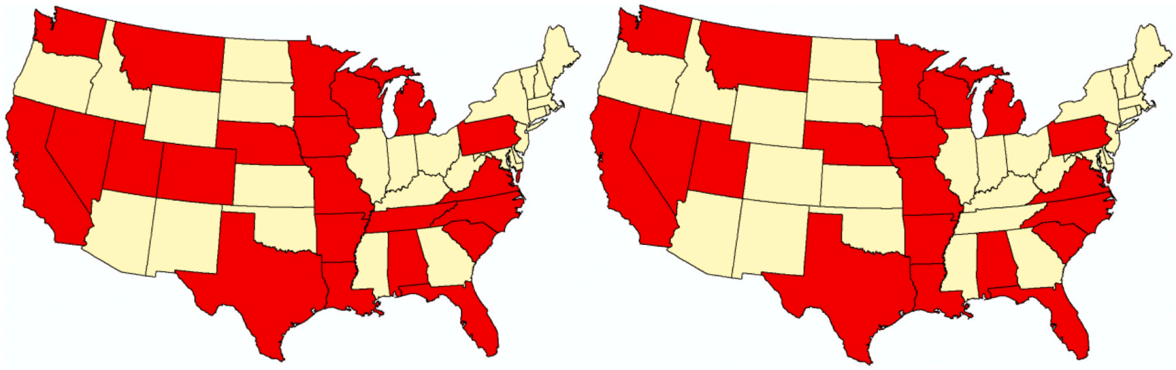

Fig. 3. Municipal broadband restrictions, 2012 (left) and 2018 (right).

Fig. 1 demonstrates the clear upwards trend for most broadband availability measures, and also suggests a "data break" between the 2013 and 2014 years when the source changed from the NBM to the FCC. The average county-level percentage of population with access to 25/3 speeds increased from 32% in 2012 to 79% in 2018, with rural population typically lagging 8–10 percentage points behind. It also shows that the percentage of population with access to fiber technology and more than one provider is much lower than the simple 25/3 measure, and that rural again lags behind the overall average for both of these measures.

3.2. Broadband policy

Our policy variables come from a combination of (1) the newly released State Broadband Policy Explorer from the Pew Charitable Trusts (Pew, 2019), which reviewed all state statutes, executive orders, and governing directives for broadband-related terms; and (2) personal emails to contacts from the State Broadband Leaders Network (SBLN) organized by the National Telecommunications and Information Administration (NTIA).

The Pew database contains over 700 entries on broadband policies going as far back as 1991, and includes the date each was introduced. It represents the first comprehensive collection of state-level broadband policies and their enacted dates; however, a deeper exploration of the data suggests that some verification is needed. For example, some statutes are listed that established a task force or agencies as of a specific date; but no information was provided about whether they consisted of full-time employees focused solely on broadband provision, or whether the group had a broader agenda with no staff dedicated explicitly to broadband.

Further, several of these organizations became defunct, and this information is not captured in the Pew dataset. Similarly, while the Pew dataset has a category for the existence of state funding programs, several of them were never allocated any actual funds to disperse. To combat these issues, we sent out emails to each of the 105 participants listed on the December 2019 version of the SBLN database, including at least one from each state. These emails asked for information about three specific types of state policy during the period 2010–2018. We received responses back from 31 of 50 states (62%), with varying degrees of detail provided. This allowed us to begin populating our policy variables for these states over our period of analysis. For states where no SBLN response was received, we used the Pew dataset and other online sources (such as lists of state broadband task forces, commissions, or authorities (NCSL, 2020) or states with restrictions on municipal broadband (Chamberlain, 2019) to compile our policy variables to the best of our ability.

Our primary policies of interest are those related to: (1) availability (and expenditure) of state-level funding, (2) existence of state-level broadband offices with full-time personnel, and (3) restrictions on municipal broadband and cooperatives. These were the

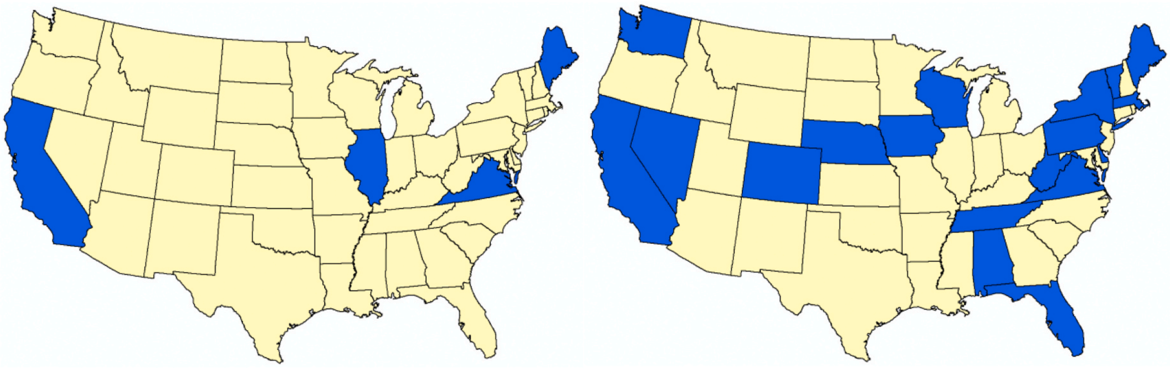

Fig. 4. State broadband funding, 2012 (left) and 2018 (right).
Source: SBLN contacts; Pew State Broadband Policy Explorer. Hawaii and Alaska not shown but included in analysis. HI and AK did not have any policies in place between 2012 and 2018.

Table 1
Descriptive statistics for broadband outcomes, policy variables, and demographics, 2012 & 2018.

		2012				2018			
		Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Outcome Measures	25/3 - all (%)	31.93	37.93	0	100	79.08	23.32	0	100
	25/3 - rural (%)	24.43	31.46	0	100	71.46	26.10	0	100
	Fiber - all (%)	7.50	18.20	0	100	24.66	28.84	0	100
	Fiber - rural (%)	6.48	15.83	0	100	21.58	27.33	0	100
	2+comp - all (%)	4.48	14.46	0	99.8	35.49	31.97	0	100
	2+comp - rural (%)	2.37	2.83	0	100	27.23	26.88	0	100
Broadband Policies	State Funds (% with)	9.86	29.82	0	100	32.96	47.01	0	100
	State Office (% with)	6.01	23.77	0	100	42.82	49.49	0	100
	Muni Restrictions (% with)	56.66	49.56	0	100	51.60	49.98	0	100
Demographic Characteristics	*All County*								
	Population	98,447	313,839	66	9,840,024	102,769	329,907	75	10,152,600
	Median HH Income	45,644	11,900	19,624	122,844	51,583	13,703	20,188	136,268
	Population Density	259.35	1725.37	0.03	69,423	269.75	1783.49	0.037	70,977
	% with Bach or more	19.50	8.75	3.72	72.81	21.57	9.43	0	78.58
	% in Poverty	16.30	6.43	0	47.70	15.60	6.48	2.30	55.10
	% Housing after 2010	0.31	0.44	0	5.60	3.59	2.64	0	36.00
	Rural % of population	56.75	33.74	0	100.00	56.71	33.80	0	100.00
	Topography	8.93	6.61	1	21.00	8.93	6.61	1	21.00
	Rural Portion of County Only								
	Population	17,358	15,512	0	123,887	17,579	15,993	0	128,275
	Median HH Income	25,468	14,858	0	91,571	28,919	17,003	0	102,156
	% with Bach or more	17.35	8.64	0	73.65	19.45	9.24	0	73.64
	% in Poverty	13.92	7.42	0	86.00	13.25	7.17	0	76.40
	% Housing after 2010	0.30	0.49	0	4.80	3.72	3.11	0	38.80
Instrumental Variables (State level)	Conservative Advantage	20.56	7.93	−20.33	36.57	16.72	9.45	−30.34	38.24
	% Repub. Legislators	58.99	12.21	0	84.28	62.53	12.82	0	87.20
# Observations		3,143				3,143			

Source: National Broadband Map, FCC Form 477, SBLN Contacts, Pew State Broadband Policy Explorer, U.S. Census (Author's Calculations).

specific policies mentioned in the email to SBLN members, with a request to document the years that each policy was in place. While we did request dollar amounts of broadband funding expended, this was not always available and in most cases could not be allocated to specific counties within the state. Thus, our initial database contains only of dummy variables for whether a specific policy was in place in a particular state for a given year, and not specific dollar amounts or number of employees. It is important to note that during the American Recovery and Reinvestment Act (ARRA) years of 2010–2014, most states received federal funding that was allocated through each state, and in many cases this funding helped set up state broadband offices. We do not include ARRA funds as state-level expenditures unless matching funds directly from the state were made available. Similarly, we do not include ARRA-funded broadband offices which only existed due to federal funds provided during the ARRA years.

The data show changes in specific types of broadband policies over the years: for example, the percentage of states with a dedicated broadband office or task force with full-time employees increased from 10% to 50% during our period of analysis, and the percentage offering some type of state-level funding rose from 8% to 36%. The percentage of states with municipal broadband restrictions slightly declined over our years of analysis from 44% to 40%, suggesting that a few states have made efforts to retract this type of legislation.

Figs. 2–4 display the states with specific policy types in the original and final years of our analysis (2012 and 2018).A full list of how the 50 states participated in each policy over the years 2012–2018 is available in Appendix A.

3.3. Other characteristics

Demographic characteristics, particularly income and education levels, have been shown to affect broadband availability (Flamm & Chaudhuri, 2007; Renkow, 2011; Whitacre & Mills, 2007). Our main empirical specification controls not only for these most well-known determinants of Internet access, but also other potentially influential characteristics such as poverty levels, population density, percentage of the population that is rural, proportion of housing built after 2010, and topography. All of these variables are compiled at the county level by aggregating Census tract-level data from the five-year American Community Survey (ACS).[5] Unfortunately, demographic variables are not available at the block level other than the FCC's population and housing estimates and decennial population. In this way, we constructed both aggregate county-level demographics and *rural-only* demographics (by aggregating only census tracts with urban population below 50%).[6] Again, we are aggregating data from a lower-order geography in an attempt to make both broadband and socioeconomic variables "compatible" as much as possible. These can be combined with our rural-only broadband availability measures to assess whether policies are having an impact in the rural parts of each county. Table 1 displays the county-level descriptive characteristics for the dependent variables, main policy variables of interest, and control variables used in our main empirical specification. It also includes two measures of political ideology that will be used as instruments, given the potentially endogenous relationship between broadband policy and availability.

Table 1 demonstrates the increases in broadband availability outcome measures that are shown in Fig. 1, but also highlights the wide variation in each of these measures. Even in 2012, some counties had 100% of their population with access to 25/3 speeds, fiber infrastructure, or 2 competitors. The average availability tracked up over time. The demographic characteristics also show increases in average population levels, income, population density, education, and the percentage of housing completed after 2010 during our period of analysis. Only the percentage in poverty and percent residing in rural areas declined between 2012 and 2018. Similar trends hold for the rural portions of counties, and again demonstrate significant variation across nearly all measures. Note that because the measures in Table 1 reflect county averages, they do not mesh exactly with the annual FCC reports on availability. For example, the 2020 FCC Broadband Report indicated that 25/3 service was available for 94% of the U.S. population in December 2018, significantly higher than our county-level average of 79.08% reported in Table 1. This is because many of our 3140 counties are below the national average in terms of availability - and each county is assigned the same weight. So, a rural county of 3000 people with no broadband availability is weighted the same as an urban county of 1 million with 100% availability – giving an average of 50% across the two counties. However, our underlying census block data does come up with the exact estimates reported by the FCC in their annual broadband reports.

3.4. Empirical methodology

The nature of our availability-focused outcome variables is inherently dynamic: values at time *t* are clearly dependent on the values at time *t-1*. It is also likely that our independent variables of interest are not exogenous, since policy enactment may be influenced by prior iterations of availability (for example, states with low or high levels of availability may be particularly interested in passing broadband policy). In such situations, dynamic panel models are often used (Arellano & Bond, 1991; Roodman, 2009). In particular, the system generalized method of moments (GMM) approach is regularly used in the economic growth literature to address endogeneity problems in the explanatory variables (Blundell & Bond, 1998; Blundell et al., 2000; Hou & Chen, 2013; Aisen & Viega, 2013). This includes efforts to explore the relationship between economic growth and broadband infrastructure (Haftu, 2019; Myovella et al., 2020).

Our working model begins with the form:

$$Availability_{it} = \rho Availability_{it-1} + \beta X_{it-1} + \gamma BBPolicy_{it-1} + \delta_t + v_i + \varepsilon_{it} \tag{1}$$

where $\boldsymbol{Availability_{it}}$ is one of three specific measures of broadband availability, $\boldsymbol{X_{it}}$is a vector of socioeconomic characteristics, $\boldsymbol{BBPolicy_{it}}$ is a vector of our three broadband policies of interest, $\delta_t$is a time dummy, v_i are county-specific effects, and $\varepsilon_{it}$is an error term; all for county *i* in year *t*. The policy measures ($BBOffice_{it}$, $BBFunding_{it}$, and $BBRestric_{it}$) are a series of dummy variables for the existence of state-level offices with full-time employees, state-level funding, and legislative restrictions on municipal or cooperative broadband, respectively. Note that the availability at time *t* is assumed to be impacted by control and policy variables from time *t-1* due to the fact that broadband provision is not an immediate process.

Equation (1) is not typically estimated with ordinary least squares because the lagged dependent variable ($\boldsymbol{Availability_{it-1}}$ in this case) is endogenous to the fixed effect v_i and thus causes a "dynamic panel bias" (Nickell, 1981). First-differencing equation (1) removes the county-level fixed effects (v_i) because they do not vary over time, and therefore eliminates the so-called Nickell bias:

[5] The exception to this is the topography variable, which is gathered from the Economic Research Service's Natural Amenities Index. The topography variable ranges from 1 (Flat Plains) to 21 (High Mountains).

[6] Our panel dataset uses the 5-year ACS estimates in the following way: 2014–2018 data was used for 2018; 2013–2017 for 2017, and so on. This is a typical approach when attempting to use 5-year ACS data for panel analysis.

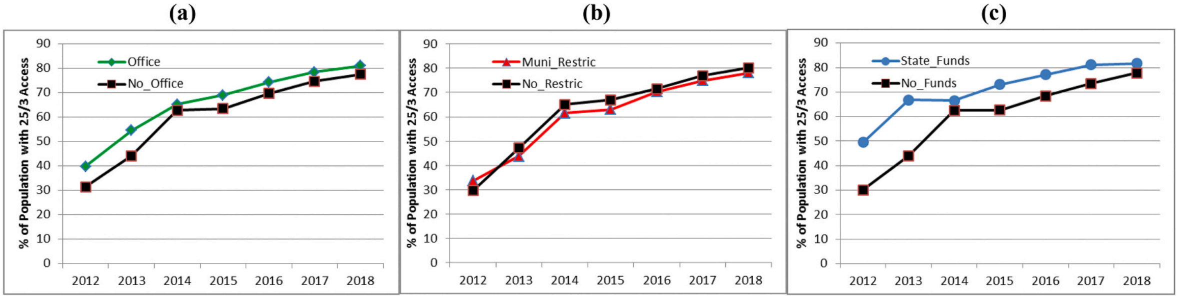

Fig. 5. Percent of population with 25/3 availability, by policy type.

$$\Delta Availability_{it} = \rho\Delta Availability_{it-1} + \beta\Delta X_{it-1} + \gamma\Delta BBPolicy_{it-1} + \Delta\delta_t + \Delta\varepsilon_{it} \tag{2}$$

However, this does not solve the potential endogeneity problem for other right-hand-side variables, namely our policy measures.[7] The solution is to use instrumental variable techniques with valid instruments that are correlated with prior iterations of availability but not with the error terms. Arellano and Bond (1991) proposed using earlier lags of independent variables *in level terms* to serve as instruments for potentially endogenous first-differenced measures; variables considered as exogenous can be used as their own instruments. This approach is known as the difference GMM estimator. Arellano & Bover (1995) further argued that this approach is made more efficient by running a system of equations (i.e. the system GMM) that combines the original equation in levels (with lagged first differences as instruments) with the existing first-differenced equation (with lagged levels as instruments).[8] This system GMM approach has been shown to have better asymptotic properties than the simpler first-differenced approach, and also results in efficient and consistent parameter estimates (Blundell and Bond, 1998). The system GMM estimator also allows traditional instruments to be included, and we use two that are assumed to be associated with our policy measures but not the broadband availability outcomes. These additional instruments are (1) the percentage of state legislators who are republican, and (2) the "conservative advantage" in political ideology, estimated by subtracting the percentage of state residents identifying as liberal from the percentage identifying as conservative. These instruments are available on an annual basis and are sourced from the National Conference of State Legislatures (NCSL, 2020) and surveys conducted in each state (Gallup, 2012–2019). We expect these instruments to influence the policy measures – hypothesizing that more conservative residents and legislatures are less likely to support state broadband offices or funding efforts, and more likely to impose municipal restrictions – but not the broadband availability outcomes. We believe that the introduction of these instruments is a novel contribution, since we could find no evidence of their use as a predictor for policy outcomes in the existing literature.

The joint validity (i.e. exogeneity) of the combined instruments is tested via the Hansen J-test of overidentifying restrictions, where the null hypothesis is that the restrictions are valid. Because dynamic panel models of the form in equation (2) typically only include a single endogenous variable, we introduce our policy measures individually, and also explore whether including them simultaneously impacts the results. We also test for the presence of autocorrelation via the Arellano-Bond AR(1) and AR(2) tests. The nature of the GMM specification implies that we should expect to reject the null of no first-order correlation (given the inclusion of a lagged dependent variable), but also that we will fail to reject the null of no second-order correlation.

The empirical approach laid out in equation (2) can also be run at the state level; that is; we could test policy impacts on state-level availability using state-level controls. The downside of this approach is that the sample size is dramatically reduced (from nearly 22,000 observations (3140 counties across 7 years) down to 350 (50 states across 7 years)) which would result in lower statistical power and a higher likelihood that the overidentifying restrictions may not be satisfied. Thus, we focus on our county-level specification but discuss the state-level results for comparison purposes.

We can also test whether states with broadband offices, grant programs, or municipal restrictions have been more successful in obtaining funding from the primary federal broadband programs. These are the FCC's Connect America Fund (CAF), which distributed over $400M in grants during the period of analysis, and the USDA's broadband-related programs, which awarded over $6.3B between 2010 and 2016. Annual information on these disbursements is available at the state, but not county, level. We find no statistical differences in USDA awards to states with/without broadband offices or with/without broadband funding programs during our period of analysis. We do, however, find significantly larger CAF awards to states *without* broadband offices or funding programs and *with* municipal restrictions in place. These statistics imply that if state policies are having their expected impacts (positive for state offices and funding programs, negative for municipal/cooperative restrictions), they are largely doing so without higher levels of financial support from the two major federally-mandated rural broadband programs.

[7] Note that the first-differenced version of our dummy policy variables highlights instances when those policies changed.
[8] As Roodman (2009) notes, the system GMM approach allows time-invariant variables (such as our topography measure) to be included whereas the difference GMM does not.

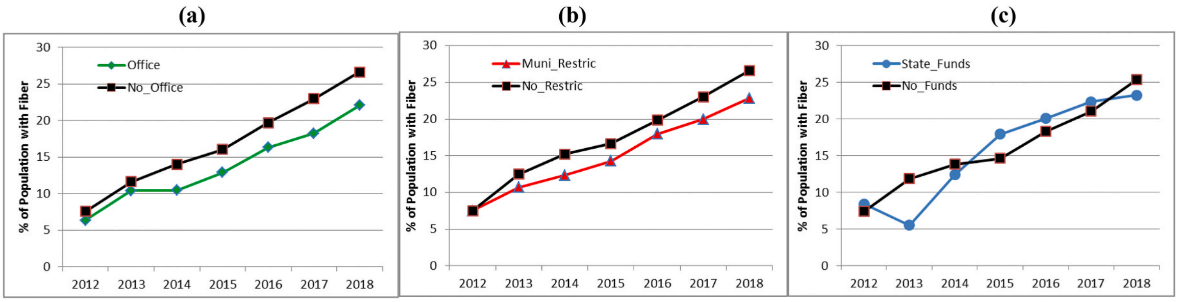

Fig. 6. Percent of population with fiber availability, by policy type.

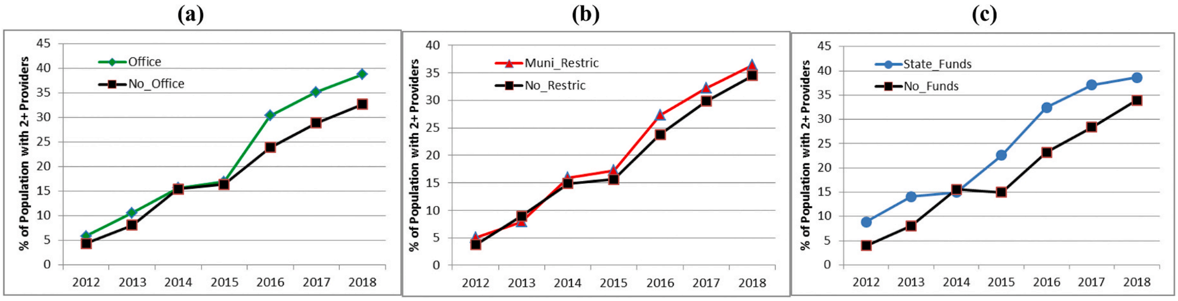

Fig. 7. Percent of population with 2+ providers (25/3), by policy type.

4. Results

4.1. Trends over time

We begin by simply noting trends in our broadband availability measures after categorizing counties into those with/without a specific policy in place during each year. If a state changes policies in a particular year (for example enacting a broadband office), the availability measures are moved into the appropriate category for that same year. In this way we can visually assess whether counties with specific types of policies in place are out-performing (or under-performing) their counterparts without such legislation. Figs. 5–7 demonstrate these results for our three main outcome variables (% with 25/3 access, % with fiber, % with 2+ providers of 25/3 speeds) across the three main policy categories.

The results for 25/3 availability do not suggest any clear advantages for counties in states with specific types of policies in place (Fig. 5). In particular, counties in states with formal broadband offices had higher rates of availability in each year; however, they trended up at a rate similar to counties in states without such offices (Fig. 5a). Similarly, counties in states with municipal broadband restrictions in place saw similar rates of 25/3 growth when compared to counties without such restrictions (Fig. 5b). And, counties in states *without* their own broadband funding program seem to be catching up to their counterparts with such funding over time (Fig. 5c).

Fig. 6 demonstrates potentially different policy outcomes when the variable of interest is switched to the percentage of households with access to fiber technology. Here, it appears that counties in states without broadband offices are outperforming those with such offices (Fig. 6a). Alternatively, counties in states without municipal broadband restrictions have seen their fiber trend line increase at a faster rate than those with such restrictions (Fig. 6b). State funding programs seem to have made an impact during the middle years of our analysis (2013–2017), but more recent data show non-participant counties catching up (Fig. 6c). Some of this variation is likely due to a dramatic increase in state-level funding in recent years (2018 in particular).

The clearest evidence of a potential positive impact of state-level policy is apparent in Fig. 7, where the focus switches to the percentage of households with 2 or more providers of 25/3 speeds. Here, counties in states with broadband offices visibly diverged from their non-office counterparts after 2015 (Fig. 7a). Similar evidence is presented for state broadband funding (Fig. 7c) where counties with such funding appear to be outpacing their counterparts after 2014. Fig. 7b is surprising in that it seems to show a higher level of competition in counties whose states limit municipal broadband, which is counter to expectations.

The above figures demonstrate some degree of correlation between specific broadband policies and availability/competition levels across counties. However, a more nuanced analysis requires consideration of other variables that are known to affect broadband access: income and education levels, percentage of population that is rural, when local housing was built, poverty rates, and others. After controlling for all of these potentially influential variables, do policies still matter? We turn to our panel regression estimates to help answer this question.

4.2. Dynamic panel regressions

Table 2 presents the results of the dynamic panel regression model for our three primary outcome variables. In each model, our data

Table 2
System GMM estimates for broadband availability.

	25/3 - All (1)		Fiber - All (2)		2+ Competitors (3)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Lag (availability)	0.433	0.013***	0.755	0.023***	0.574	0.027***
% Bachelor's Degree or More	0.141	0.031***	0.204	0.023***	0.139	0.028***
% Poverty	−0.351	0.065***	−0.128	0.042***	−0.068	0.039*
% Housing after 2010	−0.320	0.106***	0.496	0.092***	0.358	0.124***
ln(Median Household Income)	−0.008	0.020	−0.016	0.013	0.062	0.013***
ln(Population Density)	0.032	0.002***	0.000	0.001	0.020	0.002***
Rural % of Population	−0.112	0.009***	0.015	0.005**	−0.093	0.008***
Topography	0.000	0.001	−0.001	0.000	0.000	0.000
Year F.E.	Yes		Yes		Yes	
Policy Variables						
State funds	0.012	0.006*	0.020	0.005***	0.001	0.005
State office	−0.003	0.006	0.009	0.006	0.016	0.006**
Municipal restrictions	−0.031	0.009***	−0.022	0.008***	−0.018	0.008**
Constant	0.542	0.220**	0.231	0.145	0.170	0.140
Wald Chi Squared	14,568***		5,705***		18,455***	
# Instruments	54		55		61	
# Groups	3,140		3,140		3,140	
Hansen J-test	0.261		0.332		0.258	
AR(1)	0.000***		0.000***		0.000***	
AR(2)	0.336		0.231		0.150	
# Observations	18,833		18,833		18,833	

*, **, and *** represent statistical significance at the $p < .10$, .05, and 0.01 levels, respectively.
Hansen J-test represents p-values for the null hypothesis of valid instruments (overidentification).
AR(1) and AR(2) represent p-values for null hypotheses of no 1st and 2nd-order autocorrelation.

consists of 3140 counties across 7 years for a total of 21,980 observations. Because we include a lagged availability measure as a regressor, the number of observations is reduced by a full year to 18,833. Our GMM code (using the xtabond2 command in Stata) specifies the policies as endogeneous variables, and uses lagged independent variables and state-level measures of political ideology as instruments. The control variables from period *t-1* are specified as exogenous. The results in Table 2 are from a single specification with all policy variables included simultaneously; similar results hold when each policy is introduced as a single endogenous regressor.

Table 2 demonstrates that the Arellano-Bond specification largely performs as expected, including a sizable and highly statistically significant coefficient on the lagged broadband availability term. These lagged coefficients fit within the upper/lower bounds laid out in Roodman (2009) when compared to their least-squared dummy variable (LSDV) and pooled OLS alternatives.[9] Most control variables are statistically significant at the $p < 0.01$ level and have their expected signs. This includes positive impacts of education and population density, and negative impacts for poverty and the percentage of the population that is rural. These results are all consistent with previous literature (Flamm & Chaudhuri, 2007; Kolko, 2010; Renkow, 2011; Whitacre, 2008; Whitacre & Mills, 2007). Perhaps surprisingly, our measure of houses built after 2010 is negative and significant for any 25/3 availability (model (1)). This may reflect the fact that houses built before 2010 potentially made attractive targets for DSL or cable investment in the early years of broadband. The impact of this variable changes to positive and significant for fiber availability and proportion with more than 2 broadband providers, as expected. The year fixed effects (not shown) are all positive and significant, reflecting the positive trend in availability detailed in Fig. 1. These highly significant control variables give confidence that our model is behaving according to economic theory.

Turning to our variables of interest, Table 2 clearly demonstrates that state-level policies do matter for county broadband availability. Counties in states with municipal/cooperative broadband restrictions in place had availability rates that were 1.8–3.1 percentage points lower than would otherwise be expected. State funding programs resulted in higher levels (1.2–2.0 percentage points) of 25/3 availability and fiber availability. The existence of a state broadband office does not seem to impact overall 25/3 or fiber availability; however, these offices are associated with increased levels of broadband competition (1.6 percentage points higher). The specification tests demonstrate that the Arellano-Bond approach to handling endogeneity is valid. Our large number of groups (3140 counties) is more than enough to handle the sizeable number of instruments generated by including lagged versions of the dependent variables, [10] and the Hansen test fails to reject the null hypothesis of valid instruments. The AR(1) and AR(2) tests indicate the presence of first-order, but not second-order autocorrelation – the expected result for a properly specified dynamic GMM model. A robustness check that omits the less-reliable broadband data from 2012 to 2013 generates qualitatively similar results.

When the same specification is performed using state-level variables, nearly all variables lose statistical significance (results not shown). This includes most controls, with only lagged availability, population density, and rural percent of population staying significant at the $p < 0.01$ level. No policy variables – or amounts expended under federal funding programs – show up as significant under the state-level specification. Further, the state-level GMM specification rejects the Hansen J-test, likely due to the reduced number of observations and large number of instruments used to predict the policy measures. Accordingly, we focus the remaining discussion on

[9] For example, the lagged availability coefficient of 0.43 in model (1) is bounded by the LSDV estimate of 0.25 and the pooled OLS estimate of 0.59.
[10] Generally, the number of groups (units of observation over time) must be greater than the number of instruments for overidentification purposes.

Table 3
System GMM estimates for Rural Broadband Availability.

	25/3 - Rural (1)		Fiber - Rural (2)		2+ Competitors - Rural (3)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Lag (availability) - Rural	0.448	0.015***	0.818	0.025***	0.803	0.019***
% Bachelor's Degree or More – Rural	0.264	0.029***	0.095	0. 022***	0.104	0.018***
% Poverty – Rural	−0.401	0.046***	−0.091	0.028***	−0.112	0.192***
% Housing after 2010 - Rural	−0.152	0.096	0.382	0.065***	0.059	0.075
ln (Median Household Income – Rural)	−0.035	0.004***	−0.009	0.330***	−0.016	0.002***
ln (Rural Population)	0.045	0.003***	−0.010	0.168***	0.015	0.001***
Rural % of Population	0.019	0.014	0.050	0.009***	−0.008	0.006
Topography	−0.001	0.001	−0.000	0.000	0.000	0.001
Year F.E.	Yes	***	Yes		Yes	
Policy Variables						
State funds	0.018	0.007***	0.021	0.005***	0.014	0.004***
State office	−0.007	0.008	0.015	0.006**	0.003	0.005
Municipal restrictions	−0.037	0.011***	−0.016	0.006**	0.003	0.006
Constant	0.175	0.042***	0.208	0.032***	0.037	0.024
Wald Chi Squared	15,432***		7,215***		17,635***	
# Instruments	54		53		52	
# Groups	3,028		3,028		3,028	
Hansen J-test	0.251		0.304		0.275	
AR(1)	0.000***		0.000***		0.000***	
AR(2)	0.201		0.621		0.042**	
# Observations	18,159		18,159		18,159	

*, **, and *** represent statistical significance at the $p < .10$, .05, and 0.01 levels, respectively.
Hansen J-test represents p-values for the null hypothesis of valid instruments (overidentification).
AR(1) and AR(2) represent p-values for null hypotheses of no 1st and 2nd-order autocorrelation.

the more appropriately specified county-level results.

We now turn to the results of our "rural-only" county-level regressions using the rural-specific data from each county (both outcome and control variables). The results (Table 3) are generally similar to those displayed in Table 2, including meaningful impacts of most state policies.[11] In particular, state restrictions on municipal broadband lead to lower levels of 25/3 and fiber broadband in rural areas, while the existence of state-level broadband funds are associated with availability rates that are 1.4–2.1 percentage points higher for all three categories. Having a state-level broadband office is linked to higher rates of fiber availability in rural areas, but not to higher competition or overall availability. The control variables again mostly display expected signs for these rural-only specifications, although rural income is surprisingly negative for all three measures of availability.[12] Housing built after 2010 and the percentage of rural population are notably important determinants of rural fiber availability.

We note that while 25/3 speed is the current FCC threshold for broadband, this was not the case for the entire period of analysis. In fact, most states with their own broadband funding mechanisms prior to 2015 targeted 10 Mbps down/1 Mbps up deployments, which was the threshold until that time. Our results when using this alternative dependent variable show extremely similar results for the policy variable coefficients: the presence of a state funding program increased 10/1 availability by 2.2 percentage points, while municipal restrictions lowered it by 2.8 percentage points. There was no statistical impact of state-level broadband offices.

5. Conclusions

These results make a strong argument that state broadband policies are having a measurable impact on broadband diffusion across the U.S, including in rural areas. Our main findings are consistent with intuition: the existence of restrictions on municipal/cooperative broadband efforts hinders overall availability rates, while state-level broadband offices and funding programs can have positive impacts. The magnitude of the impacts is relatively small but significant: the coefficients in Table 3 imply that for a typical county with an average rural broadband availability rate of 71.5% in 2018, the presence of a state-level funding program would be expected to raise it to 73.3%. Similarly, a county in a state with municipal restrictions in place could expect to see their rural availability rise to 74.7% if the restrictions are removed. Our model argues that these effects are additive: putting both policies in place simultaneously would lead to increases of over 5 percentage points for rural broadband availability. Comparable increases would be expected for access to fiber technology in rural areas; however, increasing levels of competition in rural areas seems to be a more difficult goal for policies to accomplish.

State broadband offices with full-time employees show a positive impact for only two distinct outcomes: the percentage of residents with 2 or more providers, and rural-only fiber provision. Critics might argue that this provides evidence that such offices are not necessary,

[11] The number of observations in Table 3 is lower than in Table 2 because some counties have no rural census tracts and are therefore eliminated from the analysis.

[12] We note that there is evidence of 2nd-order autocorrelation in model (3) of Table 3, suggesting that rural competition might be influenced by lags longer than 1 year. Similar results were obtained for alternative specifications that included 2 lags of the dependent variable (and passed the resulting autocorrelation test).

given their lack of impact on overall availability (and for 4 of the 6 outcome variables). We note, however, that many states began these offices relatively recently: only 8 existed in 2014 but this number increased to 25 by the final year in our dataset (2018). The benefits of effective broadband offices are laid out in Stauffer et al. (2020), who highlight promising practices in nine states. This report points out that several such practices, including stakeholder outreach and planning/capacity building, can take time to develop. Thus, evaluations over a longer-term could find that state offices offer a delayed return on investment. Further, the interplay between state offices and the existence of other policies is unclear: it may be that office employees led the way in getting other broadband legislation passed.

Our findings are reinforced by recent momentum in the broadband policy environment: more states are moving towards creating their own broadband offices, enacting their own funding mechanisms, and removing barriers to municipal/cooperative entry. Notably, Pew's update for the 2019 legislative session – compiled after the 2012–2018 data assessed here – saw 4 states establish broadband task forces and 7 states set up their own broadband funding structures (DeWit et al., 2020). Similarly, 6 states took steps to clarify which types of entities may provide broadband, including 5 that reduced restrictions for cooperatives. Thus, even in the absence of a formal evaluation such as this, states seem to recognize what is working and legislatures are taking what they believe to be appropriate steps. This movement towards increased state intervention will find additional support from the results here.

Several limitations of this analysis exist, as well as opportunities for future analysis. In particular, federal broadband investments – namely the FCC's Connect America Fund and the USDA's broadband-related programs – are not directly included in our estimates. This is primarily because county-level estimates of amounts expended are not available for either of these programs. Preliminary analysis shows that states with broadband offices and without municipal restrictions had *lower* success in obtaining federal funding. Thus, while not including these investments may constitute omitted variable bias, the data suggest that state policy ties to federal funding are not driving the results. If anything, state policies are overcoming the more limited federal funds typically made available to them. We also note that many, if not all, state funding programs exclude applications from areas where federal funds have been received. This leads to a dilution of efficacy given that broadband networks, especially in areas with dire need of investment, are expensive. Yet, state funds cannot leverage federal funds and vice versa.[13]

As our earlier discussion noted, the quality of the FCC/NBM data is a significant limitation of our analysis. If, as many argue, the data overstates actual availability, our estimates of the impacts of specific policy measures are likely biased. The direction of this bias is an open question. For example, if the data quality generally improved over time (and areas shown as having early access in fact did not), the demonstrated policy impacts in this paper would be an understatement. Alternatively, areas incorrectly depicted as having access in later years may overstate the effectiveness of policies. We also note that our policy variables are limited by their 0/1 nature: in reality, significant variation likely exists in how states enact them. Some states have modified their municipal restrictions to be less onerous, and this heterogeneity is not captured in our estimates. Similarly, states have different enforcement or follow-up mechanisms to their funding processes. This may impact the effectiveness of such programs, but again is not captured by our analysis. Collecting and employing this more detailed policy data would be an important avenue for future research.

A separate limitation is that we do not explicitly include the concept of policy diffusion in our approach, where one state may learn from/imitate/compete with policies from its neighbors or peers (Mooney, 2001; Shipan & Volden, 2008). The mechanism underlying broadband policy diffusion could be important – particularly if it involves the interaction between state and federal funds just mentioned.[14] Additional studies could assess how broadband policies have spread over time (including the dramatic shifts seen during 2018 and 2019) and discuss implications for the future.

Finally, while the work here focused on the impact of three distinct policies on broadband availability, many more policies and outcome variables exist. For example, the PEW broadband database includes categories on mapping and promotional programs; rights-of-way and permitting legislation; and other types of funding possibilities (tax incentives/methods of financing). Assessing the impacts of these alternative policies would be a valuable contribution. Recent research has emphasized the importance of broadband adoption as opposed to simple availability (Gallardo et al., 2020; Mossberger et al., 2020), and assessing state policy impacts on adoption rates is a logical next step.

Ultimately, broadband access will continue to be an important part of our society – particularly in the aftermath of the COVID-19 pandemic. Policymakers will want to explore a variety of options for increasing both the availability and adoption of high-speed internet technology. The results here show that state-level policies do work and that they can have meaningful impacts on broadband diffusion in a U.S. context. From a practical standpoint, the results argue for prompt action: states that remove municipal broadband restrictions may see their overall availability increase by 3 percentage points, and those that offer their own funding program should see increases of 1–2 percentage points. The policy environment has changed dramatically in response to COVID-19, with significant amounts of federal broadband-related funding appropriated to a wide variety of entities – including to libraries, schools, and local governments. Monitoring and assessing the policies and programs that result is a crucial component of effectively addressing the remaining barriers to ubiquitous broadband access.

Appendix A. State-level policies in database, 2010–2018

A1 State-level Broadband Funds Expended, 2010 – 2018.

[13] We also point out that federal and most state funding is currently tied to the FCC broadband maps, which are widely acknowledged as flawed (Busby & Tanberk, 2020; Stegeman, 2019). Some rural areas are incorrectly depicted as having broadband access by these maps, and as a result are not eligible for funding.

[14] One specific category of policy diffusion laid out by Shipan and Volden (2008) is coercion, including where higher levels of government influence lower levels. The fact that state funds are not typically awarded to areas that have received federal funds may be an example of such coercion.

fips	Geography	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Alabama	0	0	0	0	0	0	0	0	1
2	Alaska	0	0	0	0	0	0	0	0	0
4	Arizona	0	0	0	0	0	0	0	0	0
5	Arkansas	0	0	0	0	0	0	0	0	0
6	California	1	1	1	1	1	1	1	1	1
8	Colorado	0	0	0	0	0	0	1	1	1
9	Connecticut	0	0	0	0	0	0	0	0	0
10	Delaware	0	0	0	1	1	1	1	1	1
11	District of Colu	0	0	0	0	0	0	0	0	0
12	Florida	0	0	0	0	0	0	0	0	1
13	Georgia	0	0	0	0	0	0	0	0	0
15	Hawaii	0	0	0	0	0	0	0	0	0
16	Idaho	0	0	0	0	0	0	0	0	0
17	Illinois	1	0	1	1	1	0	0	0	0
18	Indiana	0	0	0	0	0	0	0	0	0
19	Iowa	0	0	0	0	0	1	1	1	1
20	Kansas	0	0	0	0	0	0	0	0	0
21	Kentucky	0	0	0	0	0	0	0	0	0
22	Louisiana	0	0	0	0	0	0	0	0	0
23	Maine	1	1	1	1	1	1	1	1	1
24	Maryland	0	0	0	0	0	0	0	0	0
25	Massachusetts	0	0	0	0	0	1	1	1	1
26	Michigan	0	0	0	0	0	0	0	0	0
27	Minnesota	0	0	0	0	1	1	1	1	0
28	Mississippi	0	0	0	0	0	0	0	0	0
29	Missouri	0	0	0	0	0	0	0	0	0
30	Montana	0	0	0	0	0	0	0	0	0
31	Nebraska	0	0	0	0	0	0	1	1	1
32	Nevada	0	0	0	0	0	1	1	1	1
33	New Hampshi	0	0	0	0	0	0	0	0	0
34	New Jersey	0	0	0	0	0	0	0	0	0
35	New Mexico	0	0	0	0	0	1	0	0	0
36	New York	0	0	0	0	0	1	1	1	1
37	North Carolina	0	0	0	0	0	0	1	1	0
38	North Dakota	0	0	0	0	0	0	0	0	0
39	Ohio	0	0	0	0	0	0	0	0	0
40	Oklahoma	0	0	0	0	0	0	0	0	0
41	Oregon	0	0	0	0	0	0	0	0	0
42	Pennsylvania	0	0	0	0	0	0	0	0	1
44	Rhode Island	0	0	0	0	0	0	0	0	0
45	South Carolina	0	0	0	0	0	0	0	0	0
46	South Dakota	0	0	0	0	0	0	0	0	0
47	Tennessee	0	0	0	0	0	0	0	1	1
48	Texas	0	0	0	0	0	0	0	0	0
49	Utah	0	0	0	0	0	0	0	0	0
50	Vermont	0	0	0	0	1	1	1	1	1
51	Virginia	1	1	1	0	1	1	1	1	1
53	Washington	0	0	0	0	0	1	1	1	1
54	West Virginia	0	0	0	0	0	0	0	0	1
55	Wisconsin	0	0	0	0	1	1	1	1	1
56	Wyoming	0	0	0	0	0	0	0	0	0
	Total	**4**	**3**	**4**	**4**	**8**	**13**	**15**	**16**	**18**

A2 State Broadband Office with Full-time Employees, 2010 – 2018.

fips	Geography	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Alabama	0	0	0	0	0	1	1	1	1
2	Alaska	0	0	0	0	0	0	0	0	0
4	Arizona	0	0	0	0	0	0	0	0	1
5	Arkansas	0	0	0	1	1	1	1	1	1
6	California	1	1	1	1	1	1	1	1	1
8	Colorado	0	0	0	0	0	0	1	1	1
9	Connecticut	0	0	0	0	0	1	1	1	1
10	Delaware	0	0	0	0	0	0	0	0	0
11	District of Colu	0	0	0	0	0	0	0	0	0
12	Florida	0	0	0	0	0	0	0	0	0
13	Georgia	0	0	0	0	0	0	0	0	0
15	Hawaii	0	0	0	0	0	0	0	0	0
16	Idaho	0	0	0	0	0	0	0	0	0
17	Illinois	0	0	0	0	0	0	0	0	0
18	Indiana	0	0	0	0	0	1	1	1	1
19	Iowa	0	0	0	0	0	0	0	0	0
20	Kansas	0	0	0	0	0	0	0	0	0
21	Kentucky	0	0	0	0	0	0	0	0	0
22	Louisiana	0	0	0	0	0	0	0	0	0
23	Maine	1	1	1	1	1	1	1	1	1
24	Maryland	0	0	0	0	0	0	0	1	1
25	Massachusetts	1	1	1	1	1	1	1	1	1
26	Michigan	0	0	0	0	0	0	0	0	0
27	Minnesota	0	0	0	1	1	1	1	1	1
28	Mississippi	0	0	0	0	0	0	0	0	0
29	Missouri	0	0	0	0	0	0	0	0	1
30	Montana	0	0	0	0	0	0	0	0	0
31	Nebraska	0	0	0	0	0	0	0	0	0
32	Nevada	0	0	0	0	0	1	1	1	1
33	New Hampshi	0	0	0	0	1	1	1	1	1
34	New Jersey	0	0	0	0	0	0	0	0	0
35	New Mexico	0	0	0	0	0	0	1	1	1
36	New York	0	0	0	0	0	1	1	1	1
37	North Carolina	0	0	0	0	0	1	1	1	1
38	North Dakota	0	0	0	0	0	0	0	0	0
39	Ohio	0	0	0	0	0	0	0	0	0
40	Oklahoma	0	0	0	0	0	0	0	0	0
41	Oregon	0	0	0	0	0	0	0	0	0
42	Pennsylvania	0	0	0	0	0	0	0	0	1
44	Rhode Island	0	0	0	0	0	0	0	0	0
45	South Carolina	0	0	0	0	0	0	0	0	0
46	South Dakota	0	0	0	0	0	0	0	0	0
47	Tennessee	0	0	0	0	0	0	0	1	1
48	Texas	0	0	0	0	0	0	0	0	0
49	Utah	0	1	1	1	1	1	1	1	1
50	Vermont	0	0	0	0	0	1	1	1	1
51	Virginia	0	0	0	0	0	0	0	0	1
53	Washington	0	0	0	0	0	0	0	0	0
54	West Virginia	0	0	0	0	0	0	0	1	1
55	Wisconsin	0	0	1	1	1	1	1	1	1
56	Wyoming	0	0	0	0	0	0	0	0	1
	TOTAL	**3**	**4**	**5**	**7**	**8**	**15**	**17**	**20**	**25**

A3 State Restrictions on Municipal Broadband Provision, 2010 – 2018.

fips	Geography	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Alabama	1	1	1	1	1	1	1	1	1
2	Alaska	0	0	0	0	0	0	0	0	0
4	Arizona	0	0	0	0	0	0	0	0	0
5	Arkansas	1	1	1	1	1	1	1	1	1
6	California	1	1	1	1	1	1	1	1	1
8	Colorado	1	1	1	1	1	1	1	0	0
9	Connecticut	0	0	0	0	0	0	0	0	0
10	Delaware	0	0	0	0	0	0	0	0	0
11	District of Colu	0	0	0	0	0	0	0	0	0
12	Florida	1	1	1	1	1	1	1	1	1
13	Georgia	0	0	0	0	0	0	0	0	0
15	Hawaii	0	0	0	0	0	0	0	0	0
16	Idaho	0	0	0	0	0	0	0	0	0
17	Illinois	0	0	0	0	0	0	0	0	0
18	Indiana	0	0	0	0	0	0	0	0	0
19	Iowa	1	1	1	1	1	1	1	1	1
20	Kansas	0	0	0	0	0	0	0	0	0
21	Kentucky	0	0	0	0	0	0	0	0	0
22	Louisiana	1	1	1	1	1	1	1	1	1
23	Maine	0	0	0	0	0	0	0	0	0
24	Maryland	0	0	0	0	0	0	0	0	0
25	Massachusetts	0	0	0	0	0	0	0	0	0
26	Michigan	1	1	1	1	1	1	1	1	1
27	Minnesota	1	1	1	1	1	1	1	1	1
28	Mississippi	0	0	0	0	0	0	0	0	0
29	Missouri	1	1	1	1	1	1	1	1	1
30	Montana	1	1	1	1	1	1	1	1	1
31	Nebraska	1	1	1	1	1	1	1	1	1
32	Nevada	1	1	1	1	1	1	1	1	1
33	New Hampshi	0	0	0	0	0	0	0	0	0
34	New Jersey	0	0	0	0	0	0	0	0	0
35	New Mexico	0	0	0	0	0	0	0	0	0
36	New York	0	0	0	0	0	0	0	0	0
37	North Carolina	0	1	1	1	1	1	1	1	1
38	North Dakota	0	0	0	0	0	0	0	0	0
39	Ohio	0	0	0	0	0	0	0	0	0
40	Oklahoma	0	0	0	0	0	0	0	0	0
41	Oregon	0	0	0	0	0	0	0	0	0
42	Pennsylvania	1	1	1	1	1	1	1	1	1
44	Rhode Island	0	0	0	0	0	0	0	0	0
45	South Carolina	1	1	1	1	1	1	1	1	1
46	South Dakota	0	0	0	0	0	0	0	0	0
47	Tennessee	1	1	1	1	1	1	1	0	0
48	Texas	1	1	1	1	1	1	1	1	1
49	Utah	1	1	1	1	1	1	1	1	1
50	Vermont	0	0	0	0	0	0	0	0	0
51	Virginia	1	1	1	1	1	1	1	1	1
53	Washington	1	1	1	1	1	1	1	1	1
54	West Virginia	0	0	0	0	0	0	0	0	0
55	Wisconsin	1	1	1	1	1	1	1	1	1
56	Wyoming	0	0	0	0	0	0	0	0	0
	TOTAL	**21**	**22**	**22**	**22**	**22**	**22**	**22**	**20**	**20**

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