POLICY DETERRENCE: STRATEGIC INVESTMENT IN U.S. BROADBAND

KARAM KANG AND MO XIAO

Abstract. This paper provides new empirical evidence that firms strategically make capacity decisions to preempt government policies that promote entry and competition in the context of U.S. broadband investment. By analyzing local broadband investments in conjunction with state-level financial and regulatory policies, we uncover a robust empirical pattern that large firms increase their capacity investments in electorally competitive counties, all else equal. In contrast, small firms, which typically benefit from pro-broadband state policies, do not exhibit such a pattern. Furthermore, we observe fewer pro-broadband policies enacted in response to large firms' increased broadband capacity in electorally competitive areas. Through a simple model that considers the interplay between policymaking and market structures, we argue that large firms' ability to deter pro-competitive policies through their capacity choices may contribute to heightened market concentration.

1. Introduction

Many government policies are intended to affect market structure and industry performance, which often prompts firms to attempt to influence policies. The existing literature has focused on firms' political behavior, such as lobbying and campaign contributions to the political candidates or political action committees. One aspect that has received relatively less attention is the possibility that firms can influence policies through their business investment. To the extent that firm investment can alter market conditions and policymaking responds to these conditions—via voter pressure, ideological considerations, or other political reasons—firm investment can potentially influence policies. Importantly, such policy influences may discourage potential entrants and rival firms from investment, which, in turn, safeguard the

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Kang: Associate Professor of Economics, Department of Economics, University of Wisconsin-Madison (email: karam.kang@wisc.edu). Xiao: Professor, Department of Economics, University of Arizona (mxiao@arizona.edu). We thank Gaurab Aryal, Nathan Canen, Hülya Eraslan, Doug Hanley, Ken Hendricks, Jean-Francois Houde, Qing Huang, Zhao Li, Charles Murry, Anh Nguyen, Aniko Öry, Mattias Polborn, Michelle Sovinsky, Richard Van Weelden, and Hye Young You for their invaluable comments, and the participants at seminars and conferences.

dominant positions of the investing firms. This paper provides empirical evidence that firms invest strategically in order to preempt procompetitive government policies in the context of U.S.residential broadband services. We study local wireline investment under the influence of state-level broadband policies by (heterogeneous) Internet Service Providers (ISPs), which involves substantial cost and determines the service quality (e.g. Internet speed and reliability) that consumers receive.

This empirical context is ideal for three reasons. First, the ISPs are highly oligopolistic, predicated by the substantial return to scale of network investment and reinforced by a long and deeply-rooted tradition of government-condoned local monopoly in the U.S. telecommunications industries. Heterogeneous firms with respect to their existing network and relationships with local governments breed mixed incentives and strategies to fend off competition. Second, although the ground rules for the industry are set by federal policies, state-level policies affect entry and operating costs and, in general, directly affect providers' profitability.[1] In particular, broadband policies are often considered bi-partisan policy tools that often enter campaign platforms and policy agenda by local politicians to win the favors of local residents, without bending the politicians' innate ideology and preferences. This allows us to exploit panel variation in studying the strategic interaction among (heterogenous) firms and policymakers for a given industry. This feature contrasts to existing literature that exploits variations across industries. Third, there has been a recent stride in introducing and implementing government policies to promote broadband investment, partially driven by the public attention to "digital divide," i.e., unequal access to Internet across geographical areas and socioeconomic groups. These accommodation policies encourage entry and investment by small, local ISPs with limited geographic scope of services, generating credible threat to erode large ISPs' profitability.

We assemble data on firm investment, state policies, and local political environment that span the recent decade, 2010–2019. Our data have three main components. First, we observe each ISP's services provided for a given Census Block, as bi-annually reported by the provider to government agencies, based on which we measure firm entry and investment. Second, we manually compile all states' financial and regulatory policies on broadband investment from state legislation and other official documents.

[1]State governments issue certificates for a new ISP to enter and operate in the state, provide financial incentives through tax or subsidy policies, allocate federal funds, involve in siting decisions, and regulate ISPs. In addition, they have jurisdiction to allow the use of a public rights of way (at some compensation to be negotiated), to manage how timely they review applications and mediate ISPs' conflicts with municipalities and private landowners. See Section 2.2 for details.

This addresses one of the main challenges to studying state policies and their effects, the lack of systematic data. Third, we measure the local political environment by looking at the county-level election outcomes for state-wide or national elections such as presidential, senatorial, and gubernatorial elections. In addition, we obtain various county attributes to capture the demographic and socioeconomic variations of local population that are relevant to broadband demand and costs, as well as state government attributes such as the party and term structure of a governor and the comoposition of the state government.

Using the data, we document that local political environment, measured by the county-level vote share for a Democratic candidate in recent state-wide or national elections, matters for broadband investment. Specifically, we find that both broadband capacity and investment increase as the Democratic vote share gets closer to 50%; put differently, more investments have occurred in electorally competitive or *swing* locations. These results are robust to different measures of investment and alternative specifications. More importantly, we find that the inverted U-shaped relationship between the Democratic vote share in a county and the broadband capacity or investment in the county is mostly driven by large ISPs, even after we control for county fixed effects, state-time period fixed effects, and various other (time-varying) county attributes that may affect investment, such as population density and overall level of education of the county residents. It is notable that large firms invest more in electorally competitive areas while such patterns are not present for small firms.

We then argue that large ISPs' "extra" investment in swing counties is aimed to influence state broadband policies. In particular, these policies tend to disproportionately benefit small firms than large ones, who thus may have incentives to deter such policies. For example, policies to reduce hurdles related to poles, conduits, and rights of way can be more beneficial to small firms, who tend to be disadvantaged in navigating regulatory hurdles, than large firms, who also tend to own fiber-optic cables that have not been activated (i.e., "dark fiber"). With that, we find evidence that better broadband capacity in electorally competitive areas by large ISPs is correlated with a fewer pro-broadband policies in place. This pattern can be explained by governors being electorally accountable even for secondary issues like broadband or environmental policies (List and Sturm, 2006), who especially care about swing voters to maximize vote share (Krasa and Polborn, 2010, 2014) or the number of same-party seats in the state legislature.

In addition, the heterogeneity in the aforementioned inverted U-shape pattern in large ISPs' investment is consistent with our "policy-deterrence" interpretation. We find that the pattern is more prominent in states (i) where the average number of active large firms is smaller, and (ii) states without super-majority in either chamber of the state legislature. The benefits from preempting competition may dissipate as the number of large firms increases; either chamber of the state legislature is split, the swing locations become more valuable to the governor, and, therefore, large firms have stronger incentives to invest in swing locations to influence policies.

As such, we establish empirical evidence for a new form of preemptive investment — termed the "policy deterrence" motive — where large ISPs increase their investments to deter pro-competitive policies. We then explore the implications of this mechanism within a model where both government policies and market structures are determined endogenously in equilibrium. We examine two scenarios of a Stackelberg game involving a leader and a follower making capacity decisions. In one scenario, the policymaker commits to a policy before the firms make their choices, while in the other, policymaking is contingent on the leader's capacity decision. This policy aims to lower the marginal investment costs for the follower, thereby leveling the competitive playing field. While the model retains the traditional preemptive motive for the leader to expand capacity, it introduces a critical twist: in the second scenario, the leader can also influence the pro-competitiveness of the policy through its investment. This policy deterrence motive arises from the policymaker's preferences; if the policymaker's payoff from broadband capacity is concave — reflecting constituents' demand for broadband — the advantages of pro-competitive policies diminish as market capacity increases. Policy commitment effectively eliminates the leader's ability to employ the policy deterrence strategy, and we demonstrate that the absence of policy commitment can lead to increased capacity by the leader and greater market concentration.

Our research lies in the intersection of political economy and industrial organization. We introduce a new channel through which firms and policymakers interact. In doing so, we combine the two strands of studies: the political economy literature on firms' influence in policymaking and the IO literature on strategic investment for entry deterrence. This feature is, in part and spirit, similar to a recent theoretical paper by Callander, Foarta, and Sugaya (2022). While their emphasis is on the market distortions due to a politician's (dynamic) incentive to extract rent, our paper focuses on how firms leverage their policy influence through their investment in order to increase rivals' costs and reduce market competition. Another closely related paper, Cowgill, Prat, and Valletti (2022), looks at the relationship between political influence and market concentration. Our approach is unique in that we focus on a single industry and provides evidence from both sides in the two-way relationship, where the politicians respond to the market capacity by state policy instruments and firms respond to politicians' incentives by their investments.

In addition, we bring new dimensions to the literature on entry threat and entry deterrence. The theoretical literature points out that a firm's ability to preempt potential rivals hinges on its ability to enhance own competitive strength or burden entrants by costly irreversible investments (Wilson, 1992). The empirical evidence of preemptive behaviors is sparse in part because it is difficult to distinguish between strategic entry deterrence and nonstrategic investment decisions. One approach looks at a non-monotonic relationship between investment and market size or attractiveness (Ellison and Ellison, 2011; Gil, Houde, Sun, and Takahashi, 2021). Another approach focuses on how firm behavior changes upon a threat of potential entry (Goolsbee and Syverson, 2008; Seamans, 2012; Wilson, Xiao, and Orazem, 2021). We differ from these two approaches by exploiting the variation in political environments that firms face, conditional on other observed local attributes that affect the benefits and costs of investment. In our study, the traditional toolkit at a firm's disposal, such as predatory pricing or commitment to capacity is expanded; we rationalize firms' politically-driven investment patterns as means to deter future competition. This channel may heighten the possibility of "power begetting power" (Zingales, 2017).

Lastly, this paper belongs to a recent, burgeoning empirical literature on how firms attempt to influence government policies by their own business activities—as opposed to political activities such as campaign contributions—such as expanding employment (Carvalho, 2014; Bertrand, Kramarz, Schoar, and Thesmar, 2018), increasing bank credits (Delatte, Matray, and Pinardon-Touati, 2022), and opening subsidiaries (Bisbee and You, 2022). One potential mechanism through which these activities influence politicians is through electoral pressure, to the extent that voters care about job creation and economic development (Nordhaus, 1975), which can be affected by firm behavior. Our paper contributes to the literature by emphasizing a specific route through which firms' policy influence benefits them: maintaining or improving their competitive advantage over (potential) rivals.

2. Internet Service Providers and State Broadband Policies

An Internet Service Provider (ISP) provides Internet access to consumers, offering varied speed, reliability, and customer support at different subscription rates. In general, a U.S. household spends $20 to $100 on Internet services.[2] To deliver Internet services, ISPs build a network infrastructure that connects to Internet backbone through various technologies such as fiber optic cables, satellite links, or cellular networks. In this paper, we focus on wireline ISPs, the most common type of ISPs, which offer Internet services through cable, Digital Subscriber Lines (DSL), or fiber-optic lines. Because these technologies enable data transmission at a higher speed than the traditional narrowband, dial-up services, this industry is often referred as the "broadband" industry.

This industry is highly oligopolistic, with a handful large firms dominating the market and a large set of fringe firms with limited geographic scope of services. In the United States, the dominant players include Comcast Xfinity, AT&T, Charter Spectrum, Verizon Fios, and Cox Communications. They typically span several telecommunications areas; for example, Comcast Xfinity and Charter Spectrum provide cable TV, Internet, telephone and wireless services. These mega businesses often originated from a cable TV provider or an incumbent telephone provider, which was traditionally considered a local monopoly with substantial return to scale.

The industry is regulated by both the federal and state governments. The Federal Communications Commission (FCC) is the main regulator of this industry, while the Department of Justice (DOJ) and the Federal Trade Commission (FTC) share the responsibility for evaluating anti-competitive conduct in this industry. While the federal government deals with big picture issues, such as net neutrality and internet privacy (Greenstein, Peitz, and Valletti, 2016), the state governments implement federal policies, allocate federal funds, and, most importantly, impose their own policies to directly affect ISP's behaviors.[3]

Below, we describe prominent features in firm investment, industry composition, and policies. These industry basics and anecdotes characterize a scenario in which the possibility of two-way interactions between firms and policy makers are embedded in strategic decision makers' inherent preferences.

[2]According to a 2021 Broadband Pricing Index report, the average monthly cost of internet service is $36.33 for basic internet with download speeds of at least 25 Mbps.

[3]Within-state data transmission is considered a part of intrastate commerce and a state is the relevant regulatory body.

2.1. **Broadband Investment.** The term broadband refers to all technologies which transmit data using a wide band of frequencies, and stands in contrast to narrowband technologies (colloquially, dialup) which transmit data using one channel. While multiple channels are capable of transmitting data at faster speeds, this definition of broadband does not imply any particular speed. There are three major groups of technologies to deliver broadband: 1) Cable Modem-DOCSIS (Data Over Cable Service Interface Specifications); 2) DSL (Digital Subscriber Line), and 3) Optical Carrier/Fiber to the End User.[4] The FCC has since 2015 required speeds to meet a benchmark of 25 megabits per second (Mbps) of download speed and 3 Mbps of upload speed in order to qualify as "high-speed internet."[5]

Internet is structured like highways, with infrastructure organized into three levels: the backbone, middle mile and last mile. The backbone (a.k.a., Tier 1 networks) consists of mostly fiber-optic cables that span cross continents and oceans. During Clinton administration, the backbone Internet, initially a government-funded project, was taken over by commercial firms. The largest backbone providers nowadays include Verizon, AT&T, CenturyLink, Level 3, etc., which provide free interconnection to lower level networks (tier 2 and tier 3 networks). The "middle mile" connects the backbone network to various local aggregation points. Internet traffic is then dispensed at different aggregation points before it goes on the "last mile" to arrive at the end user (the local retail customer). In the U.S. most of the middle mile is privately owned, and owners charge fees for the usage of the part of infrastructure.Typically, tier 1 providers build an entire network from the backbone to the last mile, tier 2 providers invest in both the middle mile and last mile, and tier 3 providers only invest in the last mile.[6]

The last mile is typically the speed bottleneck; its bandwidth effectively limits the amount of data that can be delivered to the customer. The cost of building up the last-mile broadband infrastructure is substantial. For an industry example, it costs

[4]The FCC further divide these three groups into 13 types of technologies depending on the versions of these technologies.

[5]According to the Commission (FCC (2021)), "We find that the current speed benchmark of 25/3 Mbps remains an appropriate measure by which to assess whether a fixed service is providing advanced telecommunications capability. We conclude that fixed services with speeds of 25/3 Mbps continue to meet the statutory definition of advanced telecommunications capability..." Industry advocates have debated whether a download speed of 100 Mbps is a better benchmark for the modern economy.

[6]Tier 2 and 3 providers are difficult to distinguish because ISPs are reluctant to admit that they do not have control over parts of their network and, therefore, their ability to improve services may be limited.

$20,000 for fiber infrastructure per mile and $600 per home to install service from the street, in addition to $32 average monthly cost for service delivery after installation. If there are 13 homes per mile and the monthly subscription fee is $65, it would take 5.4 years to break even on the investment in the best scenario that all 13 homes subscribe to the service. This calculation varies significantly across geographies and terrains, as the cost of laying out the network is much higher in rural, remote, sparsely-populated areas. The lack of the middle mile compounds this problem. To start serving a new market, a firm with some middle-mile infrastructure may only need to build the last mile in urban areas, but may need to build its own middle mile or pay for wholesale middle-mile access in rural areas.

2.2. **State Policies and Regulatory Matters.** Beyond federal regulations, state governments have important jurisdiction over this industry. State policies and regulation, broadly speaking, include four categories: state grants and subsidies, tax incentives, right of way accommodations, and municipality provision restrictions. The last category concerns whether municipal governments are allowed to provide public Internet services, but such restrictions had little variations in our period of study (2010-2019) so we do not include it in our analysis.[7]

Grants and subsidies. Many states started an active grant or loan programs during our data period and often set up an office to management funds. States including New York, Massachusetts, Indiana and California provided between $20 million to $500 million grant programs. Such programs were often targeted toward unserved or underserved areas; for example, Vermont established a Connectivity Initiative in 2015 to deploy high-speed Internet to all service locations, and as a part of the initiative, the Public Service Department was required to publish a list of Census Blocks eligible for funding on an annual basis and to solicit proposals from providers.

Tax incentives. An example is the 2014 policy in Colorado, allowing broadband providers to get a refund on state sales/use taxes paid for broadband equipment. Another example is the 6-percent excise tax credit for broadband providers purchasing new equipment, which was enacted in 2017 in Tennessee. Tax incentives often are not targeted, not discriminating one provider or location over another, but with some

[7]Currently, 21 states restrict electric cooperatives and municipalities from providing broadband services. For example, North Carolina requires a city to hold a special election on the question of whether it can provide a communications service before the city can incur debt for building such a system. Wilson (2021) evaluates a ban on municipality provision by estimating a structural model of consumer demand and a dynamic oligopoly model of investment by public and private ISPs.

exceptions. In 2017, Indiana enacted a policy to allow local governments to adopt an ordinance designating an area as an "infrastructure development zone" and to provide eligible infrastructure in the zone with an exemption from property tax.

Rights of way accommodation. When it comes to poles, conduits and rights of way, state and local governments go beyond just issuing certificate for a new ISP to operate.[8] Section 253(c) of the Telecommunication Act of 1996 states: "Nothing in this section affects the authority of a State or local government to manage the rights of way or to require fair and reasonable compensation from telecommunication providers, on a competitively neutral and non-discriminatory basis."

The rights of way authority governs public infrastructure access for Internet deployment. Major issues include permission to build, compensation in return for granting permission (in the form of cost recovery, rental fee, or a flat tax), and the management of a public rights of way, e.g., streets and roads.[9] Somewhat mundane, minor issues include mediation when an ISP conflicts with municipalities and private landowners, and even the time frame within which an ISP application gets reviewed.[10] In addition, remediation and maintenance laws dictate issues such as in what state of repair ISPs must maintain their facilities. For example, if a sidewalk is torn in order to lay cables, these laws determine to what extent the sidewalk would need to be restored to its original state and under what time frame.

Over time in our data period, states have eased regulations on permitting, access, pole attachments, and construction. Some accommodations were big strides, for example, California in 2016 required the Department of Transportation to notify ISPs during the planning phase of department-led highway construction projects suitable for broadband conduit installation. This is called "dig-once" policy, currently in place in eight states including Minnesota, Iowa, and Colorado. Some accommodations clearly tilt the playground toward the ISPs. For example, Alabama in 2019 specified the terms under which a property owner can sue a broadband provider for damages when the provider is using an existing electric easement for broadband. It stipulates

[8]Poles and conduits regulation refer to procedures, guidelines and requirements for communications attachments under high voltage power lines and access to underground pipes and tubes for protective electric wiring. Rights of way is a term applied to pathways or corridors of access that ISPs need to secure for installing their facilities and delivering their services.

[9]In some states, an ISP needs to get permission to build on a public rights of way from each municipality, whereas in other states, this is handled by a centralized authority.

[10]In Vermont, landowner complaints can be heard on a wide range of issues including aesthetics, and decisions can be appealed to the Vermont Supreme Court. On the other extreme is Texas, where most factors cannot be appealed and landowners must pay the ISPs legal expenses if the landowners lose in court.

that property owners cannot receive more in damages than the amount that their property lost in value because broadband facilities were installed.

2.3. **Broadband in Politicians' Campaign Platform and Policy Agenda.** The broadband status (or the lack thereof) has been a recurring theme in governor campaign platforms and policy agendas in the past decade, as represented in campaign website archives, governors' state of the state addresses, and news reports.[11] This motivates our framework where politicians consider the broadband status experienced by their constituents as an important policy issue, and have incentives to push for policies that encourage entry and investment if the status is deemed inadequate.

Examples span from Mark Dayton's 2010 gubernatorial campaign for Minnesota to Chris Jones's 2022 campaign for Arkansas. Political candidates often stress on the lack of coverage in the state and the under-provision of high-speed Internet. They typically relate broadband accessibility to education, healthcare, and local businesses and economy growth.[12] Many of them would even develop concrete plans to implement their policy goals upon being elected.[13]

In addition, governors often actively pursue strategies and policies to improve the availability and affordability of broadband in the state. Similar to political candidates, incumbent politicians generally focus on the "unserved" and "underserved" areas, the first one about the coverage and the second about speed, as an inadequacy that needs to be fixed. In 2016, New York Governor Andrew Cuomo declared in his state of the state address "Upstate's roads and bridges, broadband and other infrastructure must be upgraded ... achieving parity with downstate." Different from election candidates, incumbent politicians emphasize their already implemented initiatives, strategies, and policies.[14] In 2021, 40 states discussed their broadband status and relevant policy fixes in the governors' state of the state speeches. Many of the speeches specifically mentioned the state's cooperation with entrants or small firms as a strategic plan.[15]

[11]All 50 state constitutions mandate that the governor give an annual (or regular) report to the state legislature on the condition of the state. The speech also includes the governor's priorities and goals for the legislative session.

[12]Chris Jones, running for Arkansas Governor in 2022, states in his campaign website that "our families, our classrooms, and our small businesses need affordable broadband to connect to jobs and education opportunities, and support rural communities."

[13]For example, Janet Mills, running for Maine governor in 2018, put together a detailed broadband plan, so did Jared Polis for the Colorado governor race the same year.

[14]Georgia Governor Nathan Neal stated in 2011 "I have included $44.8M in the budgets to better connect every classroom in Georgia, including those in rural areas, to the internet and digital resources students need to thrive."

[15]Alabama governor Kay Ivey stated that "I partnered with C-Spire for their $500 million dollar investment in Alabama over the next three years." North Dakota governor Doug Burgum stated

3. Data on Broadband Investment and Policymaking

We combine multiple data sources. First, data on each ISP's entry, technology, and Internet speed at the Census Block level are collected and reported bi-annually by federal agencies, first by the National Telecommunications and Information Administration (NTIA) for the period of 2010 to the first half of 2014, and then by the Federal Communications Commission (FCC) since the second semester of 2014. Second, all state-level statutes related to broadband are compiled by the PEW Charitable Trust's state broadband policy explorer.[16] Starting with the list of statutes from this source, we look at the state broadband program office websites, budget and tax expenditure documents, state laws, public statements, and news articles to construct a comprehensive and consistent dataset of broadband policies. Third, gubernatorial election results are based on CQ Press Voting and Elections Collection. We then add to these datasets with our web search for the recent election results. Lastly, we employ various demographic information from the American Community Survey.

3.1. **Broadband Deployment.** Table 1 provides how the broadband coverage and speed geographically vary during 2010–2019 by rural vs. other counties, focusing on residential services.[17] We divide counties into two groups, rural vs. rest, based on the Census definition of urban areas: if no census blocks in a county are designated as urban, we define that the county is rural. Given this definition, 702 counties are rural. During the ten years, the average fraction of population with any service availability in rural counties is 81%, the fraction with service availability by at least two providers is 24%, and the fraction with download speed greater than 25 Mbps is 44%. These statistics contrast with those of urban counties, 91%, 65%, and 68%, respectively, illustrating the persistence of the digital divide in the recent decade.

3.2. **State Broadband Policies.** Panel A of Table 2 presents summary statistics regarding various policies that were intended to encourage broadband investment. The most frequently implemented policies were rights of way accommodations.On average, each state adopted more than one pro-investment policy during our data

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"The crews from Dakota Carrier Network, Midco and other broadband providers making thousands of connections to ensure that high-speed service to schools and homes to support distance learning, earning North Dakota national recognition for our broadband connectivity."

[16]The Pew Charitable Trust's state broadband policy explorer, available at https://www.pewtrusts.org, provides the list of state laws related to access to broadband, dating back to 1991 to 2021.

[17]The FCC data distinguish residential and business services, while the NTIA data do not. To focus on residential services, we exclude the observations by business-only ISPs from the NITA data.

Table 1. Broadband Coverage and Speed: Rural vs. Urban

	Rural		Urban	
Variable	Mean	SD	Mean	SD
Coverage				
% Census Blocks with any service	54.1	26.5	65.3	20.5
% Census Blocks with 2+ ISP's	9.9	12.9	35.3	21.5
% population with any service	81.4	20.7	90.1	11.5
% population with 2+ ISP's	24.1	20.7	64.6	25.2
Speed				
% Census Blocks with $\geq$ 25 Mbps	27.3	27.7	45.6	27.1
% Census Blocks with fiber	15.5	25.8	10.2	18.3
% population with $\geq$ 25 Mbps	44.4	34.0	68.4	29.6
% population with fiber	20.3	30.5	14.7	24.2
Average max download speed (Mbps)†	146.8	190.0	206.9	198.1

Notes: 14,040 observations from rural counties (702 counties $\times$ 20 semi-annual periods, 2010-2019) and 48,780 observations from the rest counties (2,439 counties $\times$ 20). † : We take the average of the maximum download speed of the residential broadband services offered in a given county over provider-technology-block observations.

span. There were substantial variations across state and over time.[18] Some states, such as Alaska, adopted none, while others, such as Colorado, adopted such policies frequently and eventually had eleven such policies in place. There had been an increasing effort adopting such policies in the later half of our data span. Out of our data span, the pace is accelerating: by 2020, all fifty states have created a task force, commission, or authority to promote broadband; during the 2020 legislative session: 31 states adopted pro-broadband legislation or resolutions.

3.3. **Governors and Elections.** There is a large heterogeneity across states regarding the electoral support of a governor. Panel B of Table 2 shows that gubernatorial elections are typically not very competitive: the average vote margins, defined as the vote share difference between the winner and his/her runner-up, are 16.4% and the majority of the governors (57.8%) won the election with at least 10% margins. However, some gubernatorial elections can be a toss-up: for example, the vote margin in the 2006 North Carolina election is 0.2, and there are four other elections with

[18]Some states place restrictions or bans for public entities like municipalities or electric cooperatives from providing broadband Internet services. During our period, the average number of restrictions or bans in place for a given state is 0.51, but most of these restrictions were placed before 2010 so we do not have much variation during our data span.

TABLE 2. State Broadband Policies and Politics

Variable	Mean	SD	Min	Max
Panel A: Broadband investment policies				
Rights of way accommodations	0.851	1.381	0	8
Tax incentives	0.204	0.481	0	2
Grant/loan programs	0.491	0.671	0	3
Office for broadband investment	0.210	0.408	0	1
Any pro-investment policy	1.545	1.810	0	11
Panel B: Term limits, elections and politics				
Democrat governor	0.415	0.493	0	1
Governor's vote margin (%, most recent)	16.40	13.73	0.22	57.97
Governor's vote margin $\geq$ 10%	0.578	0.494	0	1
Lame-duck governor†	0.303	0.460	0	1
Divided branch	0.224	0.417	0	1
Split state legislature	0.093	0.290	0	1
Competitive state House or Senate	0.475	0.500	0	1

Notes: 550 observations (50 state $\times$ 11 years, 2009–2019, except that Broadband office data is not available for 2019).† : 1 if the sitting governor is serving his/her last term given the term limit law.

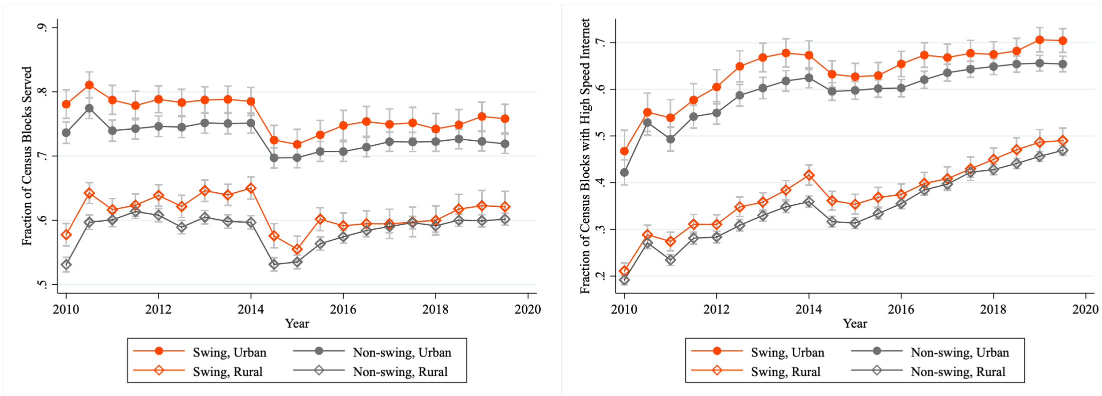
less than 1% margins during the period of study: Connecticut (2010, 0.5%), Florida (2010, 0.4%), Illinois (2010, 0.9%), and Minnesota (2010, 0.4%).

Governors' effectiveness in pushing their policy agenda can depend on the party composition of the state legislature. For example, if the majority party of the legislature differs from the party of the governor ("divided branch", 22.4% during our period of study) or the majority party of one chamber in the legislature is not the same as that of the other ("split state legislature", 9.3%), then there might be a deadlock. In addition to the majority parties of the state legislature, the extent of the majority may matter as well because more votes from the same party can help maneuver different policy preferences within the party. We define that a chamber of a state legislature, either state House or Senate, is competitive if the fraction of the majority party members is below 60%. During our sample period, having a competitive chamber in the legislature was not uncommon, 47.5%.

4. Politically-Motivated Investment

We documents that local political environment matters for broadband investment, even after we control for a multitude of demographic and socioeconomic factors, as

Figure 1. Better Broadband in Electorally Competitive Areas



(A) Coverage

(B) Speed

Notes: We group counties into four groups based on (i) whether the fraction of population living in urban area is above 2/3 (“urban,” in diamond) or not (“rural,” in circle), and (ii) whether the average Democratic vote share in recent state or national elections is 45–55% (“swing,” in orange) or not (“non-swing,” in grey). Panel (A) shows the fraction of the Census Blocks with any residential broadband Internet service, averaged across the counties in each of the four different groups. Panel (B) presents the fraction of the Census Blocks with residential broadband Internet services featuring at least 25 Mbps maximum download speed. The error bars represent 95% confidence intervals. Note that the drop in broadband capacity in 2014 is due to the change of the data collection and reporting authorities (from NTIA to FCC).

well as a rich set of fixed effects, that may also affect investment. We find a striking and robust pattern that broadband investment increases as the vote share for a Democratic candidate in state-wide (i.e., gubernatorial or Senatorial) or Presidential elections gets closer to 50%; put differently, more investments have occurred in electorally competitive or *swing* locations. In particular, we find that leading firms in a state drive this politically-charged investment pattern.

4.1. **More Broadband Investment in Swing Counties.** Figure 1 shows the average local broadband capacity, measured by the fraction of Census Blocks with any residential broadband Internet service (Panel (A)) and with high-speed service ($\geq$ 25 Mbps, Panel (B)), for four different groups of counties based on (i) whether the fraction of population living in urban area is above 2/3 (“urban,” in diamond) or not (“rural,” in circle), and (ii) whether the average Democratic vote share in recent state or national elections is 45–55% (“swing,” in orange) or not (“non-swing,” in grey).

There are two notable trends in the figure. First, the gap between rural and urban counties in broadband coverage and speed is persistent. This is the well noted “digital divide" problem.[19] Second, electorally competitive counties consistently have much better broadband capacity than non-swing (or partisan) counties, regardless of the urban/rural delineation. This is a curious pattern, suggesting the relevance of local political environment to broadband investment. The overall political viewpoints in a local area, however, may also be correlated with demographic or socioeconomic factors that are relevant to broadband investment.

To control for potential confounding factors, we consider the following specification:

$$Y_{ct} = \beta_1 DemShare_{ct} + \beta_2 (DemShare_{ct})^2 + \mathbf{X}_{ct}\beta_{\mathbf{x}} + \mu_{s(c),t} + \epsilon_{ct}, \qquad (1)$$

where Y_{ct} measures broadband investment at country c in each semi-annual period t;[20] and $DemShare_{ct}$ is the average vote share for a Democratic candidate in state-level or nation-wide elections in recent eight years for county c.[21] The vector X_{ct} consists of time-varying county attributes, including population density and size, their respective squared terms, and resident attributes listed in Table A1 in the Appendix, such as demographics (age, gender, and racial composition), income, work, and education. This specification includes state-time fixed effects, denoted by $\mu_{s(c),t}$, to account for, among other things, various state-level government policies.

Table 3 reports the OLS results based on Equation (1). We focus on one outcome measure in this baseline table for Columns (1)–(3): we use the log number of Census Blocks that were newly covered with any services plus a small positive number (0.001) to measure the investment at the extensive margin. In the last column, we instead look at the (log) number of Census Blocks with high-speed new services (at least 25 Mbps) to measure investment in the intensive margin.[22] In all four columns, there is an astonishing symmetry between the coefficients for the Democratic vote share ($\hat{\beta}_1$) and its squared term ($\hat{\beta}_2$): they are almost equal, with the former positive and the latter negative. Based on $\hat{\beta}_1$ and $\hat{\beta}_2$, all columns present a clear inverted U-shaped relation between the electorally competitiveness of a county and broadband investment to the

[19]The urban-rural disparity can be attributed to both demand- and supply-side economics in broadband deployment. In rural counties, residents tend to have lower income and are less educated than those in urban counties (Table A1 in Appendix), resulting in lower willingness to pay for broadband services. At the same time, rural counties often have difficult terrains and low population density, increasing the cost of deploying broadband networks.

[20]To consider the investment in the t^{th} period, we assume that the amount of the "time to build" is one year. For the infrequent occasions of negative deployment growth, we code investment as zero.

[21]By taking the average vote share across multiple elections, we intend to capture the local voters' political preferences, as opposed to the popularity of particular candidates.

[22]Table A2 (left panel) in the Appendix reports summary statistics on the investment variable. There seemed to be more investment in the intensive margin than in the extensive margin.

Table 3. Politically-Motivated Investment

	Investment in (log) number of blocks[a]			
	Any			≥ 25 Mbps
	(1)	(2)	(3)	(4)
Democratic vote share	9.895***	8.017***	5.145***	2.601**
	(1.011)	(1.143)	(1.215)	(1.271)
(Democratic vote share)^2	-9.478***	-8.651***	-5.321***	-2.806**
	(1.118)	(1.190)	(1.304)	(1.410)
Time-varying county attributes[b]	N	N	Y	Y
State-period FE	N	Y	Y	Y
Dem. vote share that maximizes investment	0.522	0.463	0.483	0.463
	(0.015)	(0.015)	(0.038)	(0.075)
Number of observations	49,784	49,784	49,661	49,661
Adjusted R^2	0.004	0.280	0.286	0.191

Notes: This table is based on 3,140 county × 16 semi-annual periods. We cut 4 periods from the 20 periods in the time span of our data: we do not use NITA to FCC transitional periods, December 2013 and June 2014, due to inconsistent reporting; we lose June 2019 and December 2019 data due to 2-period forward calculation of investment. The number of observations slightly changes across the columns because time-varying county attributes based on the American Community Survey are not always available. Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**), and 10% (*) levels.
On variable construction: a. The outcome variable is the logarithm of the number of census blocks with broadband investment by a given firm plus 0.001, so that we include observations with no investment. b. The time-varying county attributes include population size and density, their respective squared terms, as well as population characteristics on age, gender and race compositions, income, work, education and more, as listed in Table A1 in the Appendix.

county. Using these estimates, we calculate the Democratic vote share that maximizes investment, which equals $-\hat{\beta}_1/2\hat{\beta}_2$, and the respective standard errors. As reported by the table, across the columns, broadband investment is maximized in counties with roughly 50% Demographic vote share. In short, everything else equal, there has been more investment in electorally competitive counties.[23] We also find that this result is not driven by the quadratic functional form assumption because similar patterns appear in the spline regression results.

[23] In the Appendix, we document that these patterns are robust to using capacity, as opposed to investment, or measuring capacity or investment by the size of population residing in census blocks with service, as opposed to the number of census blocks (Tables A3 and A4).

4.2. **Large Providers Invest More in Swing Counties.** With Table 3 as a county-level overview, we focus on the decision makers behind the striking investment pattern we discover. The broadband industry features (hugely) heterogeneous providers by existing investment and network presence, with dozens of mega businesses and thousands of fringe players making location-specific investment. We divide these firms into two groups based on their market presence in a state. Specifically, some ISPs have footprint across a state, while others are dedicated to serve a few local markets. We classify an ISP as a "large" firm if the ISP provided broadband services for at least 5% of the Census Blocks within a state, averaged across the time span of this study, and a "small" firm otherwise. Given this definition, a state typically has about five ISPs that are considered as large, with the minimum two (Alaska, Hawaii, Maryland, New Mexico, and Rhode Island) and the maximum eleven (Indiana).

In this analysis, we build a balanced panel, where every county in the state is considered as a potential location for investment by a large firm while for a small firm, we consider only a subset of counties as a potential investment location: the counties where it was ever present during the period of our study. With that, the average number of counties for which a small firm is 10.6, while the average number of counties in a state is 277.4; the fraction of firm-county-period observations with any nonzero investment is 0.397 for large firms and 0.390 for small firms.[24]

We then consider the following specification:

$$Y_{fct} = \beta_1^{\tau(f)} DemShare_{ct} + \beta_2^{\tau(f)} (DemShare_{ct})^2 + \mathbf{X}_{ct}\beta_{\mathbf{x}}^{\tau(f)} + \xi_{fst}^{\tau(f)} + \mu_c^{\tau(f)} + \epsilon_{fct}, \quad (2)$$

where $\tau(f)$ represents the type of the firm, either large or small, and Y_{fct} measures the investment of firm f in county c during the period of t. Here we control for time-varying county attributes (the same as those used in Equation (1)), firm-state-period fixed effects, and county fixed effects.

Table 4 shows a clear difference between large and small firms: large firms' investment responds to Democratic vote share in the same fashion as shown in Table 3, while there is no evidence that small firms do so at all.[25] In other words, the inverted-U pattern of investment, indicating that investment is maximized in swing counties, is driven by the large firms, not by the small firms.[26]

[24]A firm may occasionally miss reporting its presence; in this situation, we impute an interpolated value using reported data in adjacent years.
[25]Table A2 (right panel) reports summary statistics on the investment variable for large and small firms respectively. Large firms invested more within a county conditioning on investment.
[26]Table A5 in the Appendix shows that the patterns here are robust to using alternative measures, either by weighing blocks using population size or by focusing on high-speed Internet only.

Table 4. Politically-Motivated Investment by Firm Size

	Investment in (log) number of blocks[a]			
	(1) Large	(2) Small	(3) Large	(4) Small
Democratic vote share	4.373***	0.292	3.431***	0.498
	(0.789)	(0.896)	(1.130)	(1.563)
(Democratic vote share)^2	-4.057***	-0.912	-3.781***	-1.178
	(0.862)	(0.954)	(1.269)	(1.754)
Time-varying county attributes[b]	Y	Y	Y	Y
Firm-state-period FE	Y	Y	Y	Y
County FE	N	N	Y	Y
Dem. vote share that maximizes investment	0.539	0.160	0.454	0.211
	(0.038)	(0.337)	(0.077)	(0.434)
Number of firms	97	1,932	97	1,932
Average (potential) counties per firm	277.39	10.58	277.39	10.58
Number of observations	248,227	196,943	248,227	196,943
Adjusted R^2	0.350	0.366	0.386	0.407

Notes: This table presents the OLS results based on a constructed balanced firm-county-time period panel. Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**) and 10% (*) levels.

On variable construction: a. The outcome variable is the logarithm of the number of census blocks with broadband investment by a given firm plus 0.001, so that we include observations with no investment. b. The (time-varying) county attributes are listed in Table A1 in the Appendix.

It is important to acknowledge that the voting behavior of residents in a county is not random. In this regard, it is reassuring that in Table 4, unobserved time-invariant county attributes and time-varying firm-state attributes are controlled for through respective fixed effects. In particular, county fixed effects account for time-invariant county attributes that are associated with demand for broadband Internet services and cost of broadband investment.

However, there may be unobserved time-varying county-firm attributes, represented as ϵ_{fct} in (2), that are correlated with both the Democratic vote share and the broadband investment. For example, mayors or other (elected) local officials may be eager to help broadband investment through various policies that boost the demand for broadband Internet services or reduce the hurdles of investment especially if they face tough elections.[27] If so, firms may be simply responding to these policies, as opposed to making preemptive investment to influence policies. However, this alternative explanation is not consistent with our finding that the inverted U-shaped relationship is not observed for small firms. In addition, state-level broadband policies tend not to be location-specific, and if anything, they target rural areas, which are often not electorally competitive (see Table A1 in the Appendix).

5. Policy-Motivated Investment and Pro-competitive Policies

Why do large firms invest more in swing locations? We argue that their investment is aimed to influence state policies. Since both investment and policies are simultaneously determined in our context, it is difficult to present a causal evidence. Instead, we build this argument by first presenting heterogeneity of large firms' investment behavior in swing counties by the market structure and the value of these counties to the state politicians. Then, we point to state broadband policies as a potential political target for large ISPs. First, these policies tend to benefit and encourage small firms to invest, which large firms may have incentives to deter. Second, broadband capacity provided by large ISPs, especially in swing counties, is negatively correlated with state broadband policies.

5.1. **Heterogeneity in Market and Political Environments.** The extent to which large firms' investment is driven by a policy deterrence motive may depend on the market structure and political environment. First, as there are many large firms operating in a state, the benefits of policy-motivated investments are dissipated among the firms, prompting them to free-ride on one another. To see this, using the data of first semester in 2010, we count the number of large firms operating in a county and then take the average at the state level. The median value is 2.34, based on which we divide the states into two groups. Columns (1) and (2) in Table 5 present the OLS results based on the specification of (2), using large firms only, for states with a fewer vs. more number of large firms, respectively.[28] We find that the inverse U-relationship documented in Table 4 is driven by the states with a fewer number of large firms.

[27]Relatedly, empirical evidence suggests that local politicians actively attract firm investment via tax incentives and subsidies (Jensen, Malesky, and Walsh, 2015; Mast, 2020; Slattery, 2020; Slattery and Zidar, 2020; Jensen, Findley, and Nielson, 2020).

[28]Because the market structure can be influenced by government policies and firm investments, we use the 2010 market structure and do not employ the data from 2010 in the regression.

Table 5. Heterogeneity in Politically Motivated Investment

	Investment in (log) number of blocks[a]					
	Num. of Large Firms[b]		Competitive Legislature[c]			
			Super majority		Slim majority	
	(1) Few	(2) Many	(3) No	(4) Yes	(5) Yes	(6) No
Democratic vote share	4.039***	4.693**	5.177***	1.369	6.707***	2.023
	(1.421)	(2.221)	(1.482)	(1.762)	(1.869)	(1.420)
(Democratic vote share)^2	-3.877**	-2.467	-6.488***	0.972	-8.852***	-1.002
	(1.724)	(2.141)	(1.691)	(1.771)	(2.195)	(1.518)
Time-varying county attributes[d]	Y	Y	Y	Y	Y	Y
Firm-state-period FE	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y
Maximized at Dem. vote share	0.521	0.951	0.399	-0.704	0.379	1.009
	(0.116)	(0.495)	(0.048)	(2.056)	(0.046)	(1.007)
Number of observations	115,609	101,643	190,895	57,332	121,823	126,404
Adjusted R^2	0.345	0.395	0.374	0.425	0.382	0.389

Notes: This table presents the OLS results, focusing on large firms' investment only (see the notes of Table 4 for the definition of large firms). The unit of observation is at the firm-county-period level, for the period of 2010–2019 (except for Columns (1) and (2), where we omit data from 2010). Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**) and 10% (*) levels.
On variable construction: *a.* The outcome variable is the logarithm of the number of census blocks with broadband investment (any technology or that with at least 25 Mbps maximum download speed) by a given firm plus 0.001, so that we include observations with no investment. *b.* We calculate the average number of large firms operating in a county at the state level using the data of the first semester of 2010. The states with the average number less than or equal to the median (2.34) are used in Column (1), and the rest are used in Column (2). *c.* We look at the party composition of both state House and Senate during a given period. We define that there is a super majority in the state legislature if the majority party of a chamber holds at least 2/3 of the seats; a slim majority if the majority party holds less than or equal to 5% more seats in both chambers. *d.* The (time-varying) county attributes are listed in Table A1.

Second, as the value of swing voters to the governor or the state legislature decreases, firms' incentives to invest in swing locations to influence policies may also diminish. One source of variation in the swing voters' value is the strength of a majority party's hold on the state legislature. Column (3) in Table 5 shows the OLS results of (2) for large firms, focusing on the states without super-majority (2/3 of the seats) in either chamber of the state legislature; Column (4) shows the counterpart for the remaining states. The results reveal that the pattern of more investment by large firms in swing locations is more pronounced for the super-majority states. A similar conclusion is drawn by comparing the OLS results for two groups of states (Columns (5) and (6)): the states where the majority party of a chamber in the state legislature has a slim advantage in the number of seats (5%) vs. the rest.

5.2. **State Broadband Policies Are Pro-competitive.** We argue that the benefits of pro-investment policies, as described in Section 3.2, are more pronounced for small firms than for large firms. First, many state policies were written with potential entrants' interests in mind. For example, Missouri in 2014 required pole attachment fees charged by local authorities to be nondiscriminatory and reasonable. For another example, Tennessee in 2017 required electric cooperatives to allow other providers nondiscriminatory access to poles and other infrastructure. These "nondiscriminatory" statutes favored new entrants that have no established relationships with local governments.

Even when state policies do not adopt an explicit language of being pro-competitive, small firms do seem to have more to gain from these policies than their large rivals. Small firms, lacking political capital and a history of interacting with state officials, are disadvantaged in navigating regulatory hurdles without the help of formal policies. Small firms are also less like to own dark fiber,[29] thus facing a higher barrier to entry and valuing financial incentives. Furthermore, small firms, perhaps because they are disadvantaged in many ways, are usually more flexible to work with local communities; as an example, 90% of Connect Illinois grants were awarded to local firms.

Overall, state broadband policies tend to facilitate entry and competition, to the point that large firms often put on battles against such policies. For example, Cable one, a large ISP, challenged rural grants to competitors in northeast Louisiana, citing that existing infrastructure in an area rendered broadband expansion grants unnecessary. For another example, "dig once" policy has been stalled in the Congress, in part due to large companies' opposition.

Consistent with these institutional arguments, we find that pro-investment state policies do increase the investment of small firms, while there's a notable contrast for large firms. Table A6 in the Appendix shows that large firms' investment is positively correlated with to tax incentives or grants (Column (1)), but with a lesser degree than small firms, but negatively correlated with accommodations for the rights of way issues (Column (3)). We find that the overall "response" of large firms to these

[29]Dark fiber refers to unused or underutilized fiber-optic cables that have not been activated, considered as potential capacity by the industry. Telecommunications giants such as Comcast, AT&T, and Century Link owns a considerable amount of dark fiber, but they typically choose not to lease them out to competitors in order to avoid cannibalization risks.

policies is statistically insignificant (Column (5)). To the extent that state policies take into account unobserved factors that are correlated with broadband investment, the correlations between state policies and investment outcomes are not causal. One important such channel might be an unobserved shock for Internet demand at the state level, which affects both investment and policy in the same direction. In that case, our policy effect parameters may be over-estimated. Our main focus, however, is the difference in policy effects among large vs. small firms. Therefore, the standing of our results on heterogeneous policy effects relies on whether the estimation bias is disproportionately distributed between these two types of firms.

5.3. **Do Policies "Respond" to Large ISPs' Investment?** Having discussed that large firms may have an incentive to deter state broadband policies, which are to promote overall investment but tend to disproportionately benefit small ISPs than large ones, we then investigate whether these policies are in fact deterred by large firms' investment, especially in swing counties. Here we consider the following specification:

$$\begin{aligned} Y_{s,y+2} &= \beta_1 SwingCap_{s,y} + \beta_2 PartisanCap_{s,y} \\ &\quad + \beta_3 SwingCap_{s,y} \times GovVote_{sy} + \mathbf{X}_{sy}\beta_{\mathbf{x}} + \eta_s + \mu_y + \epsilon_{sy}, \end{aligned}$$

where $Y_{s,y+2}$ is a variable representing broadband policies in state s and year $y+2$; specifically, we count the number of financial incentive policies (either grant or tax incentives), rights of way accommodation policies, or any policies (including these two types of policies) that promote broadband investment. We evaluate the likelihood of whether a pro-broadband policy is in place as a function of state-level attributes lagged by two years, in order to partially rule out the concerns of reverse causality and to reflect the possibility that policymaking is based on past information which is not necessarily fully up-to-date. The time-varying state attributes, $\mathbf{X}_{sy}$, include all variables of $\mathbf{X}_{cy}$ in (1) that are aggregated at the state level, as well as variables representing the political circumstances for the governor and the state legislature. This specification also includes year fixed effects and state fixed effects.

We measure the population-weighted broadband capacity provided by large ISPs for two groups of counties: swing counties (those with the average Democratic vote share in the recent 8 years of state-wide elections lying between 45% and 55%), $SwingCap_{sy}$, and the rest, $PartisanCap_{sy}$. For each county group, we sum the fraction of blocks with any broadband Internet services within a county, multiplied by the ratio of county to state population for each county in this group. This way, the counties with a larger population is weighed more, reflecting that the political

Table 6. Broadband Policies and Large ISPs' Capacity

	Tax/Grants		ROW		All	
	(1)	(2)	(3)	(4)	(5)	(6)
Capacity in swing counties (lag)[a]	-0.280	0.015	-2.030**	-3.160***	-1.692	-3.100*
	(0.712)	(0.733)	(0.973)	(1.112)	(1.508)	(1.576)
Capacity in swing counties (lag) × Governor's vote margin (in %)		0.018		0.077**		0.097**
		(0.021)		(0.035)		(0.045)
Capacity in partisan counties (lag)[b]	0.567	0.579	-1.660**	-1.610**	-1.005	-0.942
	(0.726)	(0.722)	(0.646)	(0.611)	(1.198)	(1.151)
Governor vote margin (in %)[c]	0.006	0.011	0.014	0.002	-0.006	-0.007
	(0.005)	(0.007)	(0.008)	(0.010)	(0.012)	(0.015)
Time-varying state attributes[d]	Y	Y	Y	Y	Y	Y
State FE, Year FE	Y	Y	Y	Y	Y	Y
Number of observations	400	400	400	400	400	400
Adjusted R^2	0.791	0.791	0.836	0.842	0.823	0.827

Notes: This table presents the OLS results and the unit of observation is state-year, from 2012 to 2019 (the 2010 and 2011 policy data are not used because the broadband map data is available from 2010 and we use two-year lags). Standard errors are adjusted for clustering within states. Asterisks indicate the statistical significance at the 1% (***), 5% (**) and 10% (*) levels.
On variable construction: *a*. The sum of the fraction of blocks with any broadband Internet services provided by large ISPs within a county, multiplied by the ratio of county to state population, over counties with the average Democratic vote share in the recent 8 years of elections lying between 45% and 55%. *b*. A county is labeled as "partisan" when the average Democratic vote share in the recent 8 years of elections in the county is below 45% or above 55%. *c*. We consider the most recent gubernatorial election for a sitting governor at a given year, by calculating the vote share difference with his/her runner-up. *d*. The same time-varying attributes of Table 3 are used, except that these are aggregated at the state-level (as opposed to the county-level). In addition, we also include the time-varying political circumstances for the governor and the state legislature, presented in Panel B in Table 2.

representation is by popular votes.[30] We allow that the effects of the broadband capacity on policies may vary with the governor's electoral incentives, measured by his/her vote margins in the most recent election in year y, $GovVote_{sy}$.

Table 6 shows the OLS results, featuring four key patterns. First, the number of regulatory policies that help broadband providers with the rights-of-way issues are negatively correlated with the large ISPs' broadband capacity in either swing or partisan counties (Column 3). Second, the negative correlation between the large ISPs'

[30]Note that the sum of the population weights for $SwingCap_{sy}$ ($PartisanCap_{sy}$) is the fraction of population living in swing (partisan) counties, which is typically less than one. For example,there are no swing counties in a state (e.g., Alaska), then $SwingCap_{sy}$ is zero because the populate weight is zero.

population-weighted capacity in swing counties and the number of the right-of-way accommodation policies is mitigated as the governor's vote margin increases, suggesting that the policy responses to broadband capacity by large ISP's are electorally motivated (Column 4). Third, the number of financial incentive policies through taxes, grants and subsidies is not correlated with the broadband capacity built by large ISPs (Columns 1 and 2). Fourth, considering all broadband policies that promote investment, the large ISPs' population-weighted capacity in swing counties, interacted with the governor's electoral strength, is an important determinant for policy (Column 6).

5.4. **Potential Mechanisms for Policy Deterrence.** Why are pro-investment policies less likely to be enacted as the broadband capacity, especially in electorally competitive locations, improves? One potential channel is that politicians respond to voter demand. Although broadband investment may be a secondary policy issue for voters, unlike "frontline" policy issues such as the level of government spending or the degree of income and wealth redistribution, there is empirical evidence that secondary policy issues are influenced by electoral incentives (List and Sturm, 2006). With that, politicians may care more about swing voters than others for two reasons. When there is uncertainty over the distribution of voter preferences, catering to swing voters (as opposed to say, median voters) can help a politician win an election (for example, see Krasa and Polborn (2010, 2014)). Alternatively, perhaps more seats occupied by the same-party politicians in the state legislature can be valuable for the governor to push her agenda, which explains her attention to swing locations.

An alternative channel is that broadband investment is a *quid pro quo* to politicians. Broadband investment can benefit the voters by better and cheaper Internet service availability and an inflow of money to the local economy. This can turn into a higher chance of winning for the sitting politicians, and this can be more effective for electorally competitive locations. A similar argument is made for the case of French financial markets in Delatte, Matray, and Pinardon-Touati (2022).

6. Endogenous Market Structure and Policymaking

We have shown empirical evidence for a new channel of preemptive investment: large broadband providers invest more in electorally competitive locations, while small firms do not, and such investment, in turn, may prevent state government policies that help investment by new, small firms, which we call "policy deterrence." Large broadband providers' services tend to receive more public scrutiny and media attention than those of small firms, making it easier to influence public opinion and policy-making, let alone other firms' decisions.

To study the implications of this channel on the broadband market, we consider compare two cases of a Stackelberg game where a leader makes the first move of capacity choice and then a follower chooses its own capacity, where the cases differ by policy commitment. In one case the policymaker commits to a policy prior to firm choices; in the other, policymaking is contingent on the first mover's capacity choice. Policy commitment essentially shuts down the possibility that the leader employs policy deterrence channel, allowing us to study its implications.

6.1. **Setup.** There are two firms in a market, a leader (L) and a follower (F), denoted by $i \in \{L, F\}$. These two firms make capacity choices, q_L and q_F, which is costly but is necessary for making profit. There is an additional actor, the policymaker, who decides whether to adopt pro-competitive policies, such as implementing an investment subsidy or easing the rights of way regulations, that reduce followers' investment costs only, represented by $s = 1$ for policy adoption and $s = 0$ for no adoption.[31] The cost for each firm to build their capacity q_L and q_F, respectively, is

$$c_L(q_L) = 0, \text{ and } c_F(q_F, s) = \begin{cases} 0 & \text{if } s = 1, \\ c_F q & \text{if } s = 0. \end{cases}$$

Upon the capacity choices, the market price p is determined by the market capacity $q \equiv q_L + q_F$:

$$p = A - bq,$$

where $A > 3c_F$ and $b > 0$.[32,33] Thus, the firms' payoffs are

$$\begin{aligned} \pi_L(q_L, q_F, s) &= [A - b(q_L + q_F)]\, q_L, \\ \pi_F(q_L, q_F, s) &= [A - b(q_L + q_F) - c_F(1 - s)]\, q_F. \end{aligned}$$

The politician's payoff depends on the market capacity and the policy:

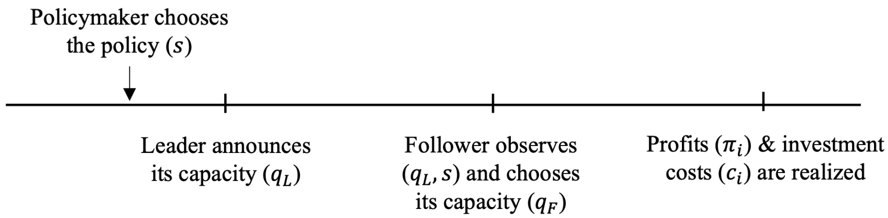
$$u(q, s) = \alpha q - \beta q^2 - \gamma s,$$

[31] This assumption is motivated by our discussion in Section 5.2 and simplifies our argument.

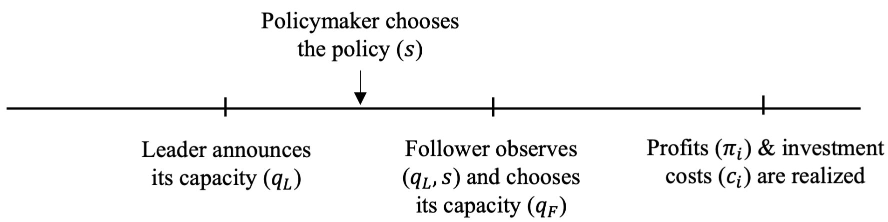
[32] We impose that A is large enough for the follower to choose a nonzero capacity even without a policy that reduces its investment cost.

[33] Instead of a two-stage game where the firms choose their capacity and then set their prices (Kreps and Scheinkman, 1983; Davidson and Deneckere, 1986), we assume that the price is determined by the market demand as in a Cournot game where firms choose quantities to simplify our discussion.

FIGURE 1. Timeline with and without Policy Commitment



(A) Policy Commitment



(B) No Policy Commitment

where $\alpha > 0$ is large enough so that at the maximal capacity A/b, the marginal payoff from increasing the total capacity, $\alpha - 2\beta A/b$, is nonnegative. The fiscal or political costs of the policy is captured by $\gamma \in (0, \alpha)$.

Given this setup, the follower's problem is identical regardless of the policy commitment. He takes both the leader's capacity and the policy as given, and maximizes its own profit as the last mover, and the solution, denoted by $q_F(q_L, s)$, is:

$$q_F(q_L, s) = \frac{A - bq_L - c_F(1-s)}{2b}.$$

Note that the leader's investment deters the follower's investment $dq_F/dq_L = -1/2 < 0$, and adopting a pro-competitive policy promotes the follower's investment: $q_F(q_L, 1) - q_F(q_L, 0) = c_F/2b > 0$ for all q_L.

6.2. **Policy Commitment.** Suppose the policymaker can commit to either adopting the policy or not, regardless of the capacity choices of the firms. The timeline for this case is depicted in Figure 1(A), where the policy is determined prior to firm moves. The game becomes a typical Stackelberg problem. The leader's capacity choice under policy s, $q_L^C(s)$, and the resulting total capacity, $q^C(s)$, are

$$q_L^C(s) = \frac{A + c_F(1-s)}{2b} \text{ and } q^C(s) = \frac{3A - c_F(1-s)}{4b}.$$

Note that the policy decreases the leader's capacity, while increasing the total capacity. Taking it account that the capacity choices depend on her policy, the policymaker chooses $s = 1$ if and only if $u[q^C(1), 1] \geq u[q^C(0), 0]$. This inequality can be written as a cutoff rule regarding the fiscal/political cost of the policy, γ:

$$(s^C, q_L^C, q^C) = \begin{cases} (1, q_L^C(1), q^C(1)) & \text{if } \gamma \leq \gamma^C \equiv c_F \left(4b\alpha + \beta c_F - 6\beta A\right)/(16b^2), \\ (0, q_L^C(0), q^C(0)) & \text{otherwise.} \end{cases} \tag{3}$$

6.3. **No Policy Commitment.** Now suppose the policymaker cannot commit to adopting or rejecting a policy a prioiri and makes her policy choice contingent on the leader's capacity choice, as presented in Figure 1(B). Her policy rule can be represented as a cutoff strategy regarding q_L: $s = 1$ if and only if

$$q_L \leq q_L^{cut} \equiv -\frac{2b}{c_F \beta}\gamma + \frac{\alpha}{\beta} + \frac{c_F}{2b} - \frac{A}{b}.$$

It is notable that $q_L^{cut} \geq q_L^C(0)$; to ensure that the policy is not adopted, the leader has to invest more than it would have under no policy. Thus, the leader's trade-off is the cost of over-investment (through lower price) vs. the benefit from fending off the follower and the policy that reduces his profit. With that, the equilibrium policy, s^{NC}, and the leader's and total capacities, (q_L^{NC}, q^{NC}) can be written as:

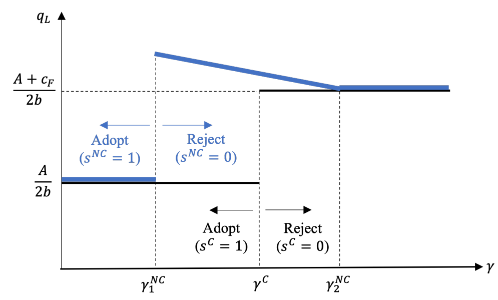
$$(s^{NC}, q_L^{NC}, q^{NC}) = \begin{cases} (1, q_L^C(1), q^C(1)) & \text{if } \gamma \leq \gamma_1^{NC}, \\ (0, q_L^{cut}, q_L^{cut} + q_F[q_L^{cut}, 0]) & \text{if } \gamma \in (\gamma_1^{NC}, \gamma_2^{NC}), \\ (0, q_L^C(0), q^C(1)) & \text{otherwise,} \end{cases} \tag{4}$$

where $\gamma_1^{NC} \equiv c_F(2\alpha b - 3A\beta - \beta\sqrt{c_F^2 + 2Ac_F})/(4b^2)$, and $\gamma_2^{NC} \equiv c_F(2\alpha b - 3A\beta)/(4b^2)$. If the policy is too costly to the policymaker to adopt (i.e., $\gamma > \gamma_2^{NC}$), then the leader will choose $q_L^C(0)$ and the policymaker will not adopt the policy; similarly, the cost is low so the policy is to be adopted anyway, then the leader will choose $q_L^C(1)$. If the cost is moderate, then the leader chooses q_L^{cut} to deter the policy.

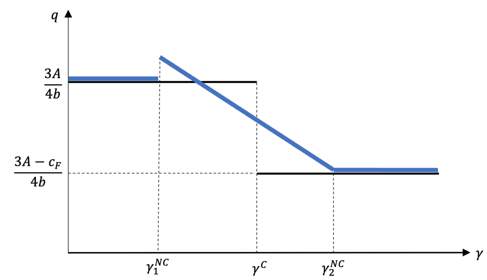
6.4. **Implications of Policy Deterrence.** The equilibrium capacities under these two scenarios, as represented in (3) and (4), differ only when the leader chooses q_L^{cut} to deter the policy, i.e., when $\gamma \in (\gamma_1^{NC}, \gamma_2^{NC})$. Here let us consider a case γ^C lies between γ_1^{NC} and γ_2^{NC}, as depicted in Figure 2.[34] In this case, the lack of policy commitment increases the leader's capacity and market share and, under certain conditions, decrease the total capacity.

[34]The condition for $\gamma^C > \gamma_1^C$ to hold is $4\alpha b - 6A\beta < \beta(c_F + 4\sqrt{c_F^2 + 2Ac_F})$.

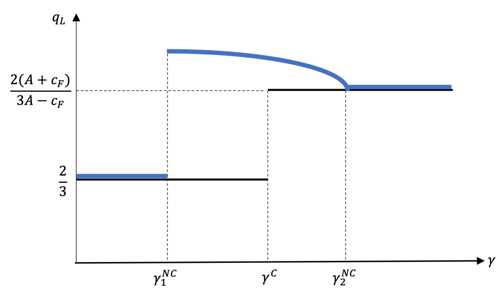
FIGURE 2. Effects of Policy Commitment



(A) Leader's Capacity



(B) Total Capacity



(C) Leader's Market Share

Notes: The figures represent the equilibrium with policy commitment (in black) and without (in blue). Panel (A) illustrates the leader's equilibrium capacity q_L and the policy adoption strategy s; Panel (B) depicts the equilibrium total capacity q; Panel (C) shows the leader's market share, defined by q_L/q.

Figure 2(A) illustrates the leader's equilibrium capacity q_L and the policy adoption strategy s with policy commitment (in black) and without (in blue). With policy commitment, the policy is adopted if and only if $\gamma < \gamma^C$, which prompts a discontinuous jump of q_L from $A/2b$ to $(A + c_F)/2b$. On the other hand, the cutoff without policy commitment is γ_1^{NC}. Below this cutoff for γ, the leader's capacity choice is the same as that with policy commitment, but the above the cutoff, the leader increases its capacity to deter the policy above the policy commitment capacity as long as γ is not too big ($\gamma < \gamma_2^{NC}$). Thus, for $\gamma \in (\gamma_1^{NC}, \gamma^C)$, the policymaker would have adopted the policy if she could commit, but does not adopt the policy without commitment.

The inability to commit induces more investment by the leader when $\gamma \in (\gamma_1^{NC}, \gamma_2^{NC})$, as illustrated in Figure 2(A). This induces the follower to invest less. The implication on the total capacity is dubious, because it depends on which force dominates the other. For example, Figure 2(B) illustrates a case where for some γ values, the total capacity is lower without policy commitment than with commitment, bur for other γ values, the opposite holds.[35] However, the effects of policy commitment on the leader's market share are not dubious, as depicted in Figure 2(C): When γ lies in the middle of two cutoffs, γ_1^{NC} and γ_2^{NC}, the lack of policy commitment increases the leader's market share, with his increased capacity per the policy deterrence motive and the ensuing decrease in the follower's capacity.

7. Conclusion

This paper provides a new channel through which firms gain competitive advantages by influencing government policies through their investment in local markets. We document a robust empirical pattern that more broadband investments occur in electorally competitive counties, and this pattern is driven by large firms. In addition, we show evidence that state policies promoting broadband investment respond to the level of broadband in the electorally competitive counties by large ISPs.

Our findings have several welfare implications. First, given that firms' policy deterrence incentives are motivated by the benefits from decreased competition, consumers may be worse off due to higher prices and perhaps lower service quality, which are often-documented outcomes of reduced competition. Second, there can be misallocation of resources, in the sense that there are more investment for electorally competitive locations, at the expense of other locations. Given that urban areas are more likely to be electorally competitive than rural areas (Table A1), the policy deterrence incentive may exacerbate the "digital divide," an uneven access to high-speed Internet across geographical areas and socio-economic groups. For example, the Federal Communications Commission (FCC) estimated that 21 million Americans, 14.5 million of them living in rural areas, still had no access to broadband services in 2019.

Last and most importantly, our findings suggest that there might be weaker government support for broadband investment than, perhaps, the socially desirable level. The effects of this inefficiency can be propagated beyond this single industry, as individuals' and households' ability to access reliable/affordable Internet has increasingly become essential to their well-being in economic, political, and social aspects. The recent COVID-19 pandemic has accelerated this trend and expanded it to remote work, online education, telehealth and telemedicine, and even the ability to

[35]If $4\alpha b - 6A\beta < c_F(b + 4\beta)$, then the effects of policy commitment on the total equilibrium capacity are indeterminate as presented in Figure 2(B). Otherwise, the capacity increase by the leader without policy commitment dominates the follower's capacity decrease, which increases the total capacity under no policy commitment.

self-isolate at home (Chiou and Tucker, 2020). The central issues discussed in this paper—the uneven competition landscape, the mis-allocated resources, and the policymaking in the U.S. broadband investment—may ultimately contribute to frictions and ill-functioning in U.S. labor market, regional growth and macro economy.

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Table A1. County Attributes: Urban vs. Rural

	Urban	Rural	Difference	SE
Average Democratic vote share	0.421	0.363	0.058***	(0.001)
Population size (in millions)	0.127	0.008	0.119***	(0.003)
% Female	0.502	0.493	0.009***	(0.000)
% Kids (aged under 5)	0.061	0.056	0.005***	(0.000)
% Senior (aged over 65)	0.162	0.200	-0.038***	(0.000)
% White	0.827	0.866	-0.039***	(0.002)
% Black	0.097	0.065	0.032***	(0.001)
% Asian	0.015	0.005	0.010***	(0.000)
% Hispanic	0.161	0.138	0.023***	(0.002)
% College-educated	0.199	0.162	0.036***	(0.001)
% In labor force	0.601	0.573	0.027***	(0.001)
% Working at home	0.042	0.070	-0.028***	(0.000)
% Commuting in long distance	0.173	0.188	-0.016***	(0.001)
% Using public transportation	0.011	0.004	0.007***	(0.000)
Average household size	2.643	2.539	0.104***	(0.003)
(log) Median household income	10.763	10.663	0.100***	(0.002)
% In poverty	0.160	0.162	-0.002***	(0.001)
% Living in an old house	0.293	0.358	-0.065***	(0.001)
Median year a house was built	1975.221	1970.175	5.046***	(0.106)
% Living in a rental property	0.291	0.243	0.047***	(0.001)
% Owning a phone	0.971	0.972	-0.001***	(0.000)
Population density	0.000	0.000	0.000***	(0.000)
Population growth rate	0.004	0.001	0.003***	(0.000)
Median household income growth rate	0.002	0.002	-0.000***	(0.000)
% College-educated growth rate	0.070	0.075	-0.005***	(0.002)

Notes: These statistics are based on 62,778 observations. An urban county refers to a county where some area within the county is categorized as urban by the Census criteria, and in a rural county, all areas are rural. The standard errors of mean differences are in parentheses.

Table A2. Summary Statistics: Broadband Investment

	Investment in (log) number of blocks			
	County-level		Firm-level	
	(1) Any	(2) $\geq$ 25 Mbps	(3) Any, Large	(4) Any, Small
Mean of investment	0.117	0.774	1.668	1.351
Fraction of any nonzero investment	0.692	0.727	0.397	0.390
Median number blocks invested (if invested)	46	73	20	9
Number of counties	3,140	3,140		
Number of firms			97	1,932
Number of observations	49,784	49,661	248,227	196,943

Notes: This table reports the extent of investment at the county-time level (left panel) and at the firm-county-time level (right panel).

Table A3. Politically-Motivated Broadband Capacity

	Capacity by blocks with any service[a]			
	(log) number		(log) population	
	Any (1)	$\geq$ 25 Mbps (2)	Any (3)	$\geq$ 25 Mbps (4)
Democratic vote share	1.222**	4.387***	2.954***	4.496***
	(0.482)	(1.248)	(0.555)	(1.012)
(Democratic vote share)^2	-1.226**	-4.022***	-2.750***	-4.111***
	(0.518)	(1.333)	(0.602)	(1.115)
Time-varying county attributes[b]	Y	Y	Y	Y
State-period FE	Y	Y	Y	Y
Dem. vote share maximizing investment	0.499	0.545	0.537	0.547
	(0.057)	(0.055)	(0.034)	(0.049)
Number of observations	62,066	62,066	62,066	62,066
Adjusted R^2	0.675	0.391	0.841	0.576

Notes: This table is based on 3,140 county $\times$ 20 semi-annual periods, with some observations dropped due to unavailability of certain variables from the American Community Survey. Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**), and 10% (*) levels. *On variable construction*: a. For Columns (1) and (2), the outcome variable is the logarithm of the number of census blocks with broadband service plus 0.001 for Columns (1) and (2). The difference between (1) and (2) lies in that we consider any broadband service for (1) while we focus on high-speed service (with at least 25 Mbps download speed) for (2). For Columns (3) and (4), we consider the weighted number of blocks, where the weight is population of each block, and add 1 when taking the logarithm to include counties without broadband service. b. The time-varying county attributes are as listed in Table A1.

Table A4. Politically-Motivated Investment: Alternative Measures

	Investment in (log) population of blocks[a]			
	Any			≥ 25 Mbps
	(1)	(2)	(3)	(4)
Democratic vote share	10.45***	7.951***	3.760***	1.694*
	(0.717)	(0.833)	(0.760)	(0.901)
(Democratic vote share)^2	-9.903***	-8.508***	-3.995***	-2.167**
	(0.821)	(0.906)	(0.852)	(1.039)
Time-varying county attributes[b]	N	N	Y	Y
State-period FE	N	Y	Y	Y
Dem. vote share maximizing investment	0.528	0.467	0.471	0.391
	(0.012)	(0.011)	(0.032)	(0.069)
Number of observations	49,784	49,784	49,661	49,661
Adjusted R^2	0.013	0.322	0.352	0.225

Notes: This table is based on 3,140 county × 16 semi-annual periods. We cut 4 periods from the 20 periods in the time span of our data: we do not use NITA to FCC transitional periods, December 2013 and June 2014, due to inconsistent reporting; we lose June 2019 and December 2019 data due to 2-period forward calculation of investment. The number of observations slightly changes across the columns because time-varying county attributes based on the American Community Survey are not always available. Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**), and 10% (*) levels.
On variable construction: a. The outcome variable is the logarithm of the population of census blocks with broadband investment plus 1, so that we include observations with no investment. b. The time-varying county attributes are as listed in Table A1.

Table A5. Politically-Motivated Investment by Firm Size: Alternative Measures

	Investment in (log) population of blocks		Investment in (log) number of blocks, $\geq$ 25Mbps	
	(1) Large	(2) Small	(3) Large	(4) Small
Democratic vote share	1.970***	-0.066	5.138***	0.268
	(0.712)	(0.950)	(1.207)	(1.585)
(Democratic vote share)^2	-2.253***	-0.190	-3.779***	-0.780
	(0.794)	(1.077)	(1.302)	(1.741)
Time-varying county attributes†	Y	Y	Y	Y
Firm-state-period FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Dem. vote share maximizing investment	0.437	-0.174	0.680	0.171
	(0.087)	(3.365)	(0.126)	(0.716)
Number of firms	97	1,932	97	1,932
Average (potential) counties per firm	277.39	10.58	277.39	10.58
Number of observations	248,227	196,943	248,227	196,943
Adjusted R^2	0.372	0.373	0.378	0.411

Notes: This table presents the OLS results based on a constructed balanced firm-county-time period panel. Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**) and 10% (*) levels. † The (time-varying) county attributes are listed in Table A1.

Table A6. Heterogeneous Response to Policy by Firm Size

	Investment in (log) number of blocks					
	(1) Large	(2) Small	(3) Large	(4) Small	(5) Large	(6) Small
Broadband policy:						
Any tax incentives/grants	0.399***	0.421***				
	(0.0456)	(0.0689)				
Any ROW accommodation			-0.293***	0.152*		
			(0.0503)	(0.0874)		
Number of all policies					-0.010	0.049**
					(0.0136)	(0.0233)
Local political environment:						
Democratic vote share	4.414***	2.418*	4.091***	1.933	3.900***	1.927
	(1.010)	(1.398)	(1.014)	(1.410)	(1.018)	(1.408)
(Democratic vote share)^2	-4.233***	-2.577	-3.714***	-1.894	-3.491***	-1.838
	(1.131)	(1.588)	(1.138)	(1.594)	(1.140)	(1.594)
County attributes†	Y	Y	Y	Y	Y	Y
Firm-period FE, County FE	Y	Y	Y	Y	Y	Y
Number of observations	248,227	193,916	248,227	193,916	248,227	193,916
Adjusted R^2	0.259	0.352	0.259	0.352	0.259	0.352

Notes: This table presents the OLS results. See the notes of Table 4 for the definition of small and large firms, the sample selection criteria, and the description of the outcome variable. Standard errors are adjusted for clustering within counties, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**) and 10% (*) levels. † : The (time-varying) county attributes are listed in Table A1, and we also include time-varying state attributes, such as the party of the sitting governor and the legislature.