POLICY DETERRENCE: STRATEGIC INVESTMENT IN U.S. BROADBAND

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ABSTRACT. This paper provides both theory and empirical evidence that firms act strategically to preempt procompetitive government policies in the context of U.S. broadband investment. We consider a simple model of a policymaker choosing policies and firms making investment in anticipation of its impact on policy choices. In the model, a leading firm can make investments to reduce the political appeal of procompetitive policies, which, in turn, blunts a following firm's investment incentives. We show the relevance of this model using data from 2010 to 2019 on local broadband investment and politics, as well as state-level financial and regulatory broadband policies. We document a robust empirical pattern that more investments occur in electorally competitive counties, and show that state policies promoting broadband investment respond more to the level of broadband in these counties. More importantly, large firms drive this investment pattern, while small firms' investment responds to policies, not to politics.

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 propel rival firms to adjust their strategies and policy responses. This paper provides both theory

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and empirical evidence that firms invest strategically in order to preempt procompetitive government policies, which, in turn, discourage competitors from investment, in the context of the Internet service providers' local broadband investment and the state-level broadband policies in the United States.

In our prototypical model, a policymaker chooses policies and two firms, a leader and a follower, make capacity choices. We present the key insight in the simplest setup: a Stackelberg capacity game with policymaking in the middle. The policy here is intended to reduce the marginal investment costs of both firms—thus promoting a larger capacity in the market—but it also levels the playing ground for the firms or is *procompetitive*, by reducing the marginal cost of the follower more than that of the leader. The model retains the traditional preemptive motive for the leader to increase capacity in a Stackelberg game, but the main twist is that the leader can also reduce the extent to which the policy is procompetitive by its investment. This new channel of preemptive investment, which we call "policy deterrence" motive, stems from the policymaker's preferences: the political appeal of procompetitive policies diminishes if the market capacity is sufficiently large. One potential explanation is that the constituents' demand for such policies may wane as they are more satisfied about the goods/services provided in the market and that policymakers are electorally accountable as they respond to such demand, in line with the existing studies(Besley and Case, 1995, 2003; List and Sturm, 2006).

We show the relevance of this model using data on all states' financial and regulatory policies on broadband investment, as well as data on local-level broadband investment from 2010 to 2019. Although the ground rules for the industry are set by federal-level policies, state-level policies affect entry and operating costs and, in general, affect providers' profitability. 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 right-of-way (at some compensation to be negotiated), to manage how timely they review applications and mediate ISPs' conflicts with municipalities and private landowners. One of the main challenges to studying state policies and their effects has been the lack of quality data. We meet this challenge by systematically compiling policies from state legislation and other official documents. Given this data, the empirical context is ideal because the markets are local, the cost of investment is substantial in the broadband industry, and there are many new (state-level) broadband policies in the recent decade.

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, with multiple confounding factors that may also affect investment controlled. Specifically, we find that broadband investment increases 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 various control variables.

We then connect this empirical finding to our theory of policy deterrence. Our theory is centered on the idea that because a firm can influence a policy through its capacity choice, its investment can increase. We view that the local political environment provides variation in the extent to which firm capacity affects policymaking. We find evidence that better broadband capacity, especially in electorally competitive areas, leads to a smaller chance of having policies to reduce the broadband investment costs in place.

An important condition for the policy deterrence motive to translate into a large investment is that the pro-investment policies by the state governments are pro-competitive, i.e., they disproportionately benefit the following firms (typically small ones) than the leading firms (large ones). We find that small firms tend to increase investment in response to pro-investment policies, while large firms don't. We also find that large firms invest more in electorally competitive areas while such investment patterns do not exist for small firms, consistent with the prediction of the model.

Our research lies in the intersection of political economy and industrial organization. We contribute to the literature by bringing in 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), but their emphasis is on the market distortions due to a politician's (dynamic) incentive to extract rent. 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 in the two-way relationship, where the politicians respond to the market capacity by state policy instruments, including regulations as well as financial incentives, and firms respond to politicians' incentives by their capacity choices.

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).

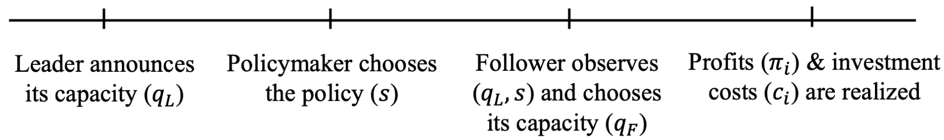
Lastly, this paper belongs to a recent, burgeoning empirical literature on how firms attempt to influence government policies by their own business activities—as opposed to political activities such as campaign contributions—such as expanding employment (Carvalho, 2014; Bertrand, Kramarz, Schoar, and 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. Model

2.1. **Overview and Setup.** This model introduces a new channel of preemptive investment, that is, a firm can directly influence government policies by its own investment. We present the key insight in the simplest setup possible, which is a Stackelberg game with policymaking in the middle.

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, which is costly but is necessary

Figure 1. Timeline of the Model



for making profit. There is an additional actor, the policymaker, whose policies affect both firms' investment costs. Government policies, such as implementing an investment subsidy or easing the right-of-way regulations, can reduce the costs. We represent such policies in one dimension, $s \in [0, 1]$, to measure the extent to which policies reduce the marginal investment costs.

The timeline is depicted in Figure 1. The leader announces its planned capacity q_L, and observing the announcement, the policymaker determines policy s.[1] Observing both the leader's capacity and the policy, the follower chooses q_F and both firms pay the corresponding investment costs. Both firms' capacities of the period determines each firm's operational profits.

2.1.1. *Firm Competition and Profits.* The operational profit of each firm is determined by the capacity levels of both firms, and is denoted by $\pi_i(q_L, q_F)$ for $i \in \{L, F\}$. This function applies to a case of monopoly ($q_F = 0$), as well as duopoly ($q_F > 0$). A firm's profit is increasing in its own capacity, but is decreasing in the competitor's capacity. In addition, a firm's profit is concave in its own capacity while convex in the competitor's capacity, and an increase in the competitor's capacity reduces the firm's marginal profit gain from increases in its own capacity. We further assume that the extent of such a reduction for the leader, i.e., $|\partial^2 \pi_L(q_L, q_F)/\partial q_L \partial q_F|$, is larger than the extent to which the follower's capacity decreases its own marginal profit gain from its capacity increase.

Assumption 1 (**Firm Profits and Competition**). *(i) For the leader, we have*

$$\frac{\partial}{\partial q_L}\pi_L(q_L, q_F) \geq 0, \quad \frac{\partial}{\partial q_F}\pi_L(q_L, q_F) \leq 0.$$

[1]Because the policy affects the leader's investment cost, as well as the follower's, the leader may have an incentive to make a false announcement, and we assume that the cost of making a false announcement is high enough to deter such a behavior.

Similar inequalities hold for the follower. (ii) The following inequalities hold for the leader and similar ones hold for the follower:

$$\frac{\partial^2}{\partial q_L^2}\pi_L(q_L, q_F) < 0, \quad \frac{\partial^2}{\partial q_F^2}\pi_L(q_L, q_F) \geq 0, \quad \frac{\partial^2}{\partial q_L \partial q_F}\pi_L(q_L, q_F) \leq 0.$$

(iii) We assume that

$$\frac{\partial^2}{\partial q_F^2}\pi_F(q_L, q_F) \leq \frac{\partial^2}{\partial q_L \partial q_F}\pi_L(q_L, q_F).$$

The assumptions above are satisfied for a large class of firm competition. An example is when the operational profit is determined by a linear demand for homogeneous goods (for example, $d(q_L + q_F) = A - b(q_L + q_F)$ and $\pi_L(q_L, q_F) = q_L d(q_L + q_F)$). For an instance, $\partial^2 \pi_F / \partial q_F^2 = -2b$ and $\partial^2 \pi_L / \partial q_L \partial q_F = -b$, satisfying Assumption 1(iii).

2.1.2. *Investment Costs.* Increasing capacity requires costly investment, and we denote the cost by $c_i(q_i, s)$ for each firm $i \in \{L, F\}$.[2] We assume that the cost is convex in the firm's own capacity. In addition, government policies reduce the marginal cost of investment.

Assumption 2 (**Investment Costs**). *(i) The cost of investment is increasing and convex for both firms. For $i \in \{L, F\}$, $q_i \geq 0$ and any s,*

$$\frac{\partial}{\partial q_i}c_i(q_i, s) \geq 0, \quad \frac{\partial^2}{\partial q_i^2}c_L(q_i, s) \geq 0,$$

with strict inequality holding for some values of q_i. (ii) The higher the value of s, the lower the the marginal cost of investment for both firms. For $i \in \{L, F\}$,

$$\frac{\partial^2}{\partial q_i \partial s}c_i(q_i, s) < 0.$$

2.1.3. *Policymaker Preferences.* The policymaker values a high broadband capacity, representing her constituents' preferences (under electoral pressure), and perhaps she may or may not view that policies that reduce broadband investment costs are desirable, based on her ideology, career concerns, or relationships with local industries. Note that these policies are not without costs; for example, negative consequences may include a higher expenditure to pay for subsidies and more complaints from pedestrians and property owners by relaxing the right-of-way regulations and proceedings. Furthermore, there is a political cost of enacting a policy, in terms of time

[2]Given that our model is one-period, the capacity choice is essentially equivalent to an investment decision, especially when the capacity function is firm-specific and thus incorporates the initial capacity level differences, among others.

and energy to reach to a consensus in the legislature, which may increase with the extent to which the policy reduces investment costs. We represent the payoff of the policymaker, reflecting all these considerations, as a function of the total broadband capacity, $q \equiv q_L + q_F$, and the policy, by $u(q, s)$.

Assumption 3 (**Policymaker's Payoff**). *(i) The policymaker's payoff function satisfies the following standard conditions:*

$$\frac{\partial}{\partial q}u(q,s) \geq 0, \quad \frac{\partial^2}{\partial q^2}u(q,s) \leq 0, \quad \frac{\partial^2}{\partial s^2}u(q,s) \leq 0.$$

(ii) The appeal for the policy decreases as the capacity increases:

$$\frac{\partial^2}{\partial s \partial q}u(q,s) < 0.$$

The first set of the assumptions are standard: the policymaker prefers better broadband capacity for her constituents, all else equal, but its marginal value is not increasing. Although we do not place a restriction on the sign of the marginal value of a policy, the third inequality in the above assumption implies that the payoff is concave in the extent to which the policy promotes investment.

Assumption 3(ii) implies that the marginal increase in the politician's payoff from enacting a more pro-investment policy reduces as the capacity increases. One potential explanation or justification is that the constituents' demand for policies to reduce investment costs may wane as the broadband infrastructure gets more satisfactory. This is an interesting and important assumption that allows the leader to have influence on policymaking by building its own capacity.

2.2. **Follower's Response.** Given that players in the model move sequentially, we solve the model backwards, starting with the follower's problem.

$$\max_{q_F} \pi_F(q_L, q_F) - c_F(q_F, s).$$

By Assumptions 1(ii) and 2(i), it can be seen that an increase in the leader's capacity deters the follower's investment:

$$\frac{dq_F}{dq_L} = -\left\{\frac{\partial^2}{\partial q_F^2}\pi_F(q_L,q_F) - \frac{\partial^2}{\partial q_F^2}c_F(q_F,s)\right\}^{-1}\frac{\partial^2}{\partial q_L \partial q_F}\pi_L(q_L,q_F) \leq 0. \tag{1}$$

Similarly, it is straightforward to see that, by Assumptions 1(ii) and 2, as the policy promotes investment, the follower responds accordingly:

$$\frac{dq_F}{ds} = \left\{\frac{\partial^2}{\partial q_F^2}\pi_F(q_L,q_F) - \frac{\partial^2}{\partial q_F^2}c_F(q_F,s)\right\}^{-1}\frac{\partial^2}{\partial q_F \partial s}c_F(q_F,s) \geq 0. \tag{2}$$

2.3. **Policymaking.** The policymaker maximizes her payoff given the leader's capacity (announcement):

$$\max_s u(q_L + q_F(q_L, s), s)$$

Taking the first order condition:

$$\frac{\partial}{\partial s}u(q,s) + \frac{\partial}{\partial q}u(q,s)\frac{\partial}{\partial s}q_F(q_L,s) = 0. \tag{3}$$

This equation represents that the policymaker considers the policy's direct impact on her payoff, as well as its indirect impact through the follower's investment.

How does the leader's capacity influence policymaking? To see this, denoting the left-hand side of the policymaker's first order condition by $P(q_L, s)$ and applying the Implicit Function Theorem to (3), it can be seen that

$$\frac{ds}{dq_L} = \left(1 + \frac{dq_F}{dq_L}\right)\left(\frac{\partial^2 u}{\partial q^2}\frac{dq_F}{ds} + \frac{\partial^2 u}{\partial q \partial s}\right) \Big/ \left(-\frac{\partial}{\partial s}P(q_L, s)\right) \leq 0. \tag{4}$$

In short, the policymaker enacts a less pro-investment policy as the leader's broadband capacity increases. The right-hand side of (4) provides the intuition for this prediction. The first term represents how the leader's capacity affects the total equilibrium capacity. Although an increase in the leader's capacity leads to a decrease in the follower's capacity, the effects on the total capacity are positive by Assumptions 1(iii) and 2. The second term represents how the total capacity increase affects the marginal benefit of the policy, which is negative because the policymaker's payoff is concave in capacity and she finds the benefit of the policy wanes with the capacity level (Assumption 3). Noting that the denominator is positive (the negative value of the policymaker's second order condition), we conclude that the leader's capacity increase lowers the strength of the policy in promoting investment.

2.4. **Leader's Incentive to Deter Policy.** The leader's problem is:

$$\max_{q_L} \pi_L\left(q_L, q_F\left(q_L, s(q_L)\right)\right) - c_L(q_L, s(q_L)).$$

The above problem makes it clear that the leader does not take q_F or s as given because the leader moves before policy-making and the follower's move.

The first order condition is:

$$\begin{aligned}&\frac{\partial}{\partial q_L}\pi_L(q_L, q_F) + \frac{\partial}{\partial q_F}\pi_L(q_L, q_F)\left\{\frac{dq_F}{dq_L} + \frac{dq_F}{ds}\frac{ds}{dq_L}\right\} \\ &-\frac{\partial}{\partial q_L}c_L(q_L, s) - \frac{\partial}{\partial s}c_L(q_L, s)\frac{ds}{dq_L} = 0.\end{aligned} \tag{5}$$

The first line of (5) represents the marginal benefit of investment, and the second line represents the marginal cost. The leader's marginal benefit includes two strategic components, deriving from the investment's impact on the follower's action. First, the leader's capacity directly crowds out the follower's investment, following (1). Second, by (4), as the leader builds up its capacity, the policy intervention is reduced, which indirectly reduces the follower's investment, as shown in (2).

While the first component has been studied in the existing literature, the second one is new. If the leader's capacity does not directly affect the government policy, i.e., $ds\,/\,dq_L = 0$, then this second component is zero. The firm capacity's negative influence on policies that invite more competition increases the marginal benefit of investment.

The leader's cost of making additional investment is also affected, as represented by the last term of (5). Under Assumptions 2(ii) and 3, the marginal cost of investment is higher when considering the investment's impact on policy; a larger investment leads to a less support from the government for paying for the investment.

2.5. **Policymaker's Preferences and Firm Behavior.** Given our discussions, we then study the role of political environment or policymaker preferences in shaping the firm capacity choices and the market competition. For a start, we introduce a parameter, $\gamma > 0$, which represents the extent to which the policymaker values the broadband capacity, and assume that for any (q, s, γ),

$$\frac{\partial^2}{\partial q \partial \gamma} u(q, s; \gamma) > 0. \tag{6}$$

By taking the derivative of (5) with respect to γ, we can write the leader's response to an increase in the policymaker's preference for broadband as follows:

$$\frac{dq_L}{d\gamma} = A(q_L, \gamma)\frac{ds}{d\gamma} + B(q_L, \gamma)\left[\frac{\partial \pi_L}{\partial q_F}\frac{\partial q_F}{\partial s} - \frac{\partial c_L}{\partial s}\right]\frac{d^2 s}{dq_L d\gamma},$$

where $A(q_L, \gamma) \leq 0$ and $B(q_L, \gamma) \geq 0$ for all (q_L, γ), given our assumptions on the profit and the cost functions.

In determining the sign of $dq_L/d\gamma$, we see that there are two counteracting forces or channels. The first channel concerns the direct impact of the policymaker's preference for broadband on her policy choice ($ds/d\gamma$). The more the policymaker cares about broadband, the more she would promote it (i.e., $ds/d\gamma \geq 0$). To the extent that this policy boost serves as an extra competitive advantage for the follower, this channel lowers the incentive for the leader to increase its capacity.

The second channel relates to the impact of the policymaker's preference on the leader's policy influence ($d^2s/dq_Ld\gamma$). As the policymaker pays more attention to the broadband capacity, the leader's influence on her policy choice can increase ($d^2s/dq_Ld\gamma \leq 0$). As long as the marginal benefit of deterring the follower outweighs the higher cost of investment, both through a weaker government support for investment costs, the leader may take advantage of its amplified influence and increase its capacity.

If the second channel prevails over the first one, the leader increases its capacity in response to an increase in γ. The follower, on the other hand, reduces its capacity for two reasons. First, as the leader further increases its capacity, making it less profitable for the follower to make an investment. Second, the ensuing policy is less supportive of new investment in terms of marginal costs, further depressing the follower's incentive to invest.

3. Institutional Background and Data

3.1. **Broadband Industry.** In the broadband industry, the (sunk) cost of investment, such as installing fiber-coaxial or fiber-optic cables or digital subscriber lines, is substantial.[3] For an industry example, it costs \$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.

The industry is regulated by both the federal and state governments. 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 and impose their own policies to directly affect ISP's behaviors: they 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.

When it comes to poles, conduits and right of way, state and local governments have an important role: Section 253(c) of the Telecommunication Act of 1996 states:

[3]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. The FCC, however, 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 broadband services.

"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." These governments have jurisdiction to allow the use of a public right-of-way, e.g., streets, roads, etc., dedicated or acquired as right-of-way. In some states, an ISP is supposed to get permission to build on a public right-of-way from every single municipality that the project crosses, whereas in other states, this is handled by a centralized authority. The governments also decide compensation in return for granting such a permission in the form of cost recovery, rental fee, or a flat tax.

In addition, they manage how timely they review applications and mediate ISPs' conflicts with municipalities and private landowners. In Vermont, landowner complaints can be heard on a wide range of issues including aesthetics, and decisions are appealable to the Vermont Supreme Court. On the other extreme is Texas, where most factors are not appealable and landowners must pay the ISPs legal expenses if they lose in court. Remediation and maintenance laws, as determined by state or local governments, 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.

3.2. **Data Sources.** We combine multiple data sources to construct the data for the analyses. 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.[4] 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; information on governor term limits is sourced from Klarner (2013). We then add to these datasets with our web

[4]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.

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 × 20 semi-annual periods, 2010-2019) and 48,780 observations from the rest counties (2,439 counties × 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.

search for the recent election results. To complement these data, we obtain various demographic information from the American Community Survey.

3.3. **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.[5] 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, and the rest are not. 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 other counties, 91%, 65%, and 68%, respectively, illustrating the persistence of the digital divide in the recent decade.

3.4. **State Broadband Policies.** Panel A of Table 2 presents some summary statistics regarding various policies that were intended to encourage broadband investment. The most frequently implemented policies were right-of-way accommodations, which

[5]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.

set rules for ISPs to use public infrastructure and facilities for broadband deployment. States have eased regulations on permitting, access, pole attachments, and construction over time in our data period. Some accommodations were major, 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. Some 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 (and, therefore, favored new entrants that have no established relationships with local governments).

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

Many states started an active grant or loan programs the data period and often set up an office to management funds. States including New York, Massachusetts, Indiana and California provided between $20m to $500m grant programs. Such programs were often targeted; 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.

On average, each state adopted more than one pro-investment policy during our data span. There were substantial variations across state and over time.[6] 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

[6]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				
Right-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				
Lame duck†	0.303	0.460	0	1
Vote margins, most recent election (%)	16.404	13.728	0.218	57.973
Vote margins, most recent election $\geq$ 10%	0.578	0.494	0	1
Democratic Governor	0.415	0.493	0	1
Divided Branch	0.224	0.417	0	1
Split Legislature	0.093	0.290	0	1
Competitive State Senate or House	0.475	0.500	0	1

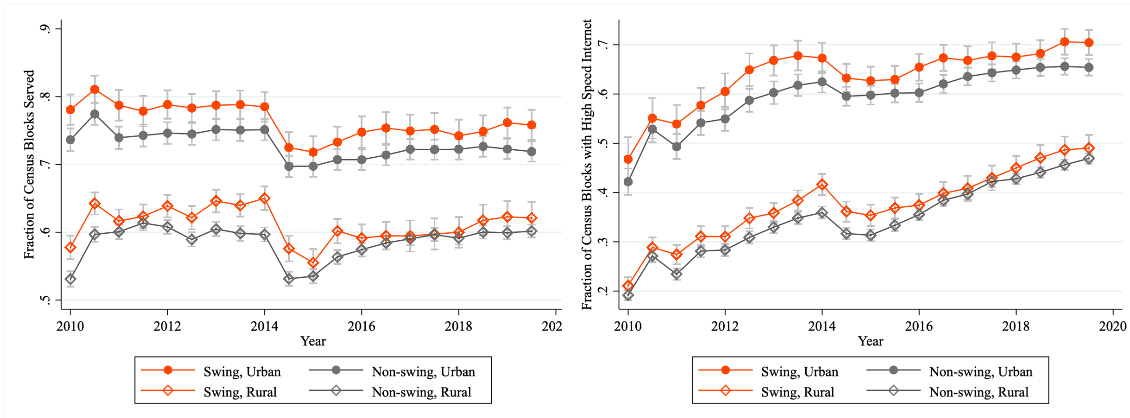
Notes: 550 observations (50 state × 11 years, 2009–2019, except that Broadband office data is not available for 2019). † : 1 if the sitting governor is serving his/her last term given the term limit law.

force, commission, or authority to promote broadband; during the 2020 legislative session: 31 states adopted pro-broadband legislation or resolutions.

3.5. **Governors and elections.** There is a large heterogeneity across states regarding the term limits and the electoral support of a governor. During 2008–2018, 14 states did not have a term limit for governors (Connecticut, Iowa, Indiana, Illinois, Massachusetts, Minnesota, North Dakota, New Hampshire, New York, Texas, Utah, Washington, Wisconsin); Wyoming used to have a two-term limit but the state Supreme Court invalidated it in 2014; and the remaining 35 states had a term limit (for two terms, except Virginia which allows for one term). Panel B of Table 2 shows that the probability that the sitting governor is serving his/her last term given the state term limit law (or he/she is a "lame-duck" governor) is 0.3.

The table 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 less than 1% margins during the period of study:

FIGURE 2. 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). The left panel shows the fraction of the Census blocks with any residential broadband Internet service, averaged across the counties in each of the four different groups. The right panel 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).

Connecticut (2010, 0.5%), Florida (2010, 0.4%), Illinois (2010, 0.9%), and Minnesota (2010, 0.4%).

4. Political Environment and Firm Investment

This section documents that local political environment matters for broadband investment, when controlling for other factors that may also affect investment. Specifically, we find that broadband investment increases as the vote share for a Democratic candidate gets closer to 50%; put differently, more investments have occurred in electorally competitive or *swing* locations.

Figure 2 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 versus urban counties in broadband service availability is persistent. In urban counties, residents tend to have higher income and are better educated than those in rural counties (Table A1 in Appendix). Income and education, among other things, are positively correlated with demand or willingness to pay for broadband services, partially explaining this observed divide.

Second, electorally competitive counties tend to have better broadband capacity than others, and this pattern is observed among both urban and rural counties. This may suggest that local political environment may matter in broadband investment. However, the overall political viewpoints in a local area may also be correlated with demographic or socioeconomic factors that are relevant to the demand for and the cost of broadband services.

To control for various factors that may also affect broadband capacity of a location, we consider the following specification:

$$Y_{ct} = \beta_1 DemShare_{ct} + \beta_2 (DemShare_{ct})^2 + \mathbf{X}_{ct}\beta_{\mathbf{x}} + \eta_t + \mu_{s(c),y(t)} + \epsilon_{ct}, \qquad (7)$$

where Y_{ct} measures broadband investment at country c in each semi-annual period t; 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.[7] To consider the investment in the t^{th} period, we assume that the amount of the "time to build" is one year. 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. In addition to semi-annual time fixed effects, this specification includes state-year fixed effects, denoted by $mu_{s(c),y(t)}$, to account for, among other things, various (yearly) state-level government policies.

Table 3 reports the OLS results based on (7). We use two outcome measures: in the first three columns, the log number of Census Blocks covered with any services measures the investment at the extensive margin; and in the last column, the log number of Census Blocks with download speed greater or equal to 25 Mpbs measures investment in the intensive margin. All columns present a clear non-monotonic, concave relation between the electorally competitiveness of a county and broadband

[7]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.

Table 3. Politically Driven Investment

	Investment in (log) number of blocks			
	Any			≥ 25 Mbps
	(1)	(2)	(3)	(4)
Democratic vote share	9.871***	8.014***	5.141***	2.599**
	(1.010)	(1.139)	(1.211)	(1.267)
(Democratic vote share)^2	-9.457***	-8.648***	-5.317***	-2.805**
	(1.118)	(1.186)	(1.300)	(1.405)
Time-varying county attributes†	N	N	Y	Y
Time FE	N	Y	Y	Y
State-Year FE	N	Y	Y	Y
Maximized at Dem. vote share	0.522***	0.463***	0.483***	0.463***
	(0.015)	(0.015)	(0.038)	(0.075)
Mean of the dependent variable	0.117	0.117	0.117	0.774
Number of observations	49,792	49,784	49,661	49,661
Adjusted R^2	0.004	0.255	0.261	0.154

Notes: This table presents the OLS results are based on 3,139 county × 16 semi-annual periods (we do not use NITA to FCC transitional periods (December 2013 and June 2014), and we lose June 2019 and December 2019 data due to 2-period forward calculation of investment). The number of observations vary 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. †: 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.

investment to the county. In all three 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. The third last row reports the estimates of the Democratic vote share that maximizes investment, which equals $-\hat{\beta}_1/2\hat{\beta}_2$, and the respective standard errors. Across the columns, broadband investment is maximized in counties with roughly 50% Demographic vote share. In short, everything else equal, firms tend to invest more in electorally competitive counties.

5. Supporting Evidence for Policy Deterrence

The present section shows that the empirical finding in the previous section that politics matter for broadband investment can be rationalized by our theory of policy deterrence. Our theory posits that because a firm can influence a policy through its capacity, it may invest more. The local political environment can provide variation in the extent to which firm capacity affects policymaking. Section 5.1 presents evidence that such policy influence through investment in the electorally competitive areas is higher than in other areas.

As demonstrated in our model, a larger policy influence doesn't necessarily translate into a larger market capacity. One of the key conditions is that the pro-investment policies disproportionately benefit the follower than the leader. In Section 5.2, we compare the investment behavior of large versus small firms, and find that small firms tend to increase investment in response to pro-investment policies, while large firms don't. We also find that large firms drive the results in Section 4; in other words, large firms invest more in electorally competitive areas while such investment patterns do not exist for small firms, echoing the predictions in Section 2.5. We then discuss alternative explanations in Section 5.3.

5.1. **Policymaking and Broadband Capacity.** Our theory hinges on the idea that the appeal for policies to reduce the cost of broadband investment to the policymaker decreases as the voters, especially those located in electorally competitive locations, enjoy better broadband infrastructure. This, in turn, manifests in policymaking, where such broadband policies are less likely enacted and implemented as the broadband capacity (in electorally competitive locations) expands.

We test this idea using our data on state-level policies, as described in Section 3.4, where pro-investment policies include right-of-way accommodations, tax incentives, grants, and loans. We consider the following specification:

$$Y_{s,y+2} = \beta_2 AvgCap_{sy} + \beta_1 SwingCap_{sy} + \mathbf{X}_{sy}\beta_{\mathbf{x}} + \eta_y + \mu_s + \rho_s y + \epsilon_{sy},$$

where $Y_{s,y}$ is a dummy variable indicating that any pro-investment policy is in place in state s and year y. 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.

Specifically, we look at the effects of the broadband capacity on policies, where we measure the capacity in two ways: state capacity (as measured by the average fraction of the population covered with high-speed ($\geq$ 25 Mbps) broadband across all counties within a state), $AvgCap$, and the relative capacity in swing counties (as measured by the capacity counterpart among swing counties minus the average capacity), $SwingCap$. Whether a county is categorized as swing, or electorally competitive, for

TABLE 4. Pro-investment Policies and Broadband Capacity

	A pro-investment policy is in place			
	(1)	(2)	(3)	(4)
Avg. capacity in all counties	0.100		0.066	0.057
	(0.179)		(0.183)	(0.181)
Avg. relative capacity in swing counties		-0.179**	-0.171*	-0.181*
		(0.088)	(0.097)	(0.096)
Avg. relative capacity in partisan counties				-0.128
				(0.118)
Time-varying state attributes†	Y	Y	Y	Y
State FE, Year FE	Y	Y	Y	Y
State-specific time trend	Y	Y	Y	Y
Number of observations	400	400	400	400
Adjusted R^2	0.892	0.894	0.893	0.894

Notes: This table presents the OLS results and the unit of observation is state-year, from 2010 to 2017 (we lose 2018 and 2019 data because we evaluation the outcome variable two years later). Standard errors are adjusted for clustering within states. †: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 variables in Panel B in Table 2, which represent the political circumstances for the governor and the state legislature.

a given year is determined by the average Democratic vote share in recent state-wide or national elections. Here, the range of the average Democratic vote share for a swing county is 45–55%. In an alternative specification, we also include the relative capacity in partisan counties, those with the average Democratic vote share below 40% or above 60%.

The time-varying state attributes, $\mathbf{X}_{sy}$, include all variables of $\mathbf{X}_{cy}$ in (7) that are aggregated at the state level, as well as variables representing the political circumstances for the governor and the state legislature, summarized by those in Panel B in Table 2. This specification also includes year fixed effects, state fixed effects, and state-specific time trends.

Table 4 shows the OLS results. We find that a 1 percentage point increase in the relative capacity of swing counties is associated with roughly a 0.18 percentage point decrease in the probability that a state pro-investment policy for the broadband providers is in place. It is notable that such policy responsiveness is not observed for all counties, nor for partisan counties' relative capacity.

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). An interesting point here is that politicians may care more about swing voters than others, and this emerges as an equilibrium if political candidates maximize their winning probability under uncertainty over the distribution of voter preferences. This is because with this uncertainty, maximizing winning probability and maximizing vote share are typically identical objectives for candidates (for example, see Krasa and Polborn (2010, 2014)).

Given this suggestive empirical evidence of and potential mechanism for the notion that better broadband capacities in electorally competitive locations reduce the chance that a pro-investment policy for broadband Internet services is enacted, we interpret that the value of γ, as defined in (6), is higher for electorally competitive counties than for other counties.

5.2. **Large vs. Small Providers.** Our model considers two types of firms: Some firms (leaders) lead the market and influence the (state-level) policy, while others (followers) take both leaders' decisions and policies as given and respond to them. In connecting these theoretical distinctions to data, we argue that firm size in a given state is an important factor for two reasons. First, the quantity and quality of services provided by large broadband providers (ISPs), such as Comcast and AT&T, receive more public scrutiny and media attention than those of small firms, making it easier to influence other firms' decisions, public opinion, and policy-making. Relatedly, large firms tend to be more politically active than small ones, by, for example, providing campaign contributions to politicians and hiring professional lobbyists to represent their interests in the government. Second, as a firm serves more locations within a state, the firm's incentive for policy deterrence may increase.

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 Internet 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. Based on 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).

Another important assumption for policy deterrence is that the benefits of a pro-investment policy are more pronounced for followers (or small firms in our empirical context) than for leaders (or large firms). Without observing the investment costs of firms, we infer these heterogeneous effects by looking at how firms respond to a pro-investment policy. We consider the following specification for firm f:

$$\begin{aligned} Y_{fct} = \gamma_1^{\tau(f)} Policy_{s(c)t} + \gamma_2^{\tau(f)} DemShare_{ct} + \gamma_3^{\tau(f)} (DemShare_{ct})^2 \\ + \mathbf{X}_{ct}\gamma_{\mathbf{x}}^{\tau(f)} + \eta_t^{\tau(f)} + \xi_f + \epsilon_{fct}, \end{aligned} \tag{8}$$

where $\tau(f)$ represents the type of the firm, either large or small. This specification is adapted from the county-level specification (7) to conduct firm-county-level analyses and to explicitly control for the state-level (time-varying) policies (as opposed to including state-year fixed effects). The main variables—for example, Y_{fct}—are the same as before, except that they are at the firm-county-period level, and the time-varying county attributes, $\mathbf{X}_{ct}$, include time-varying state attributes, such as the party of the sitting governor and the legislature, which are absorbed in state-year fixed effects in (7).

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. We argue that the electoral circumstances of the sitting governor, as measured by his/her lame duck status and voter support in the most recent election, are uncorrelated the unobserved factors affecting broadband investment, because the electoral circumstances of a sitting governor are transitory while broadband investment decisions are likely to be based on the long-term profitability. Specifically, our instruments are the two year lags of the lame duck indicator, vote margins, the interaction between these two variables.

These instruments are inspired by List and Sturm (2006), and the first stage estimates are presented in Table A2 in the Appendix. We find that a governor is less likely to bring in a policy to encourage broadband investment when she cannot be reelected due to the state term limit, relative to when she can. However, this difference gets smaller when the voter support for the governor is large. These findings are similar to those of List and Sturm (2006), although they look at state-level environmental spending. These findings show that policy-making responds to electoral incentives, even for secondary policies.

Table 5 reports the IV results. We find that pro-investment policies do increase the investment of small firms, especially in terms of the extent or quantity of service

(Column 2), while such effects are not statistically significant for large firms. These results are consistent with an important condition for an investment due to the policy deterrence motive: the heterogeneous benefits of pro-investment policies on leaders versus followers. This heterogeneity could be partially driven by the leader's advantage in leveraging the existing infrastructure and relationships, and also by potential frictions in the financial market that disproportionately increase financial costs to followers, as opposed to leaders. In this regard, the pro-investment policies seem to be procompetitive, in the sense that it levels the playing field by helping small firms more than large ones.

It is notable that the non-monotonic, concave relationship between investment and the Democratic vote share, as documented in Table 3, is present for large firms (Columns 1 and 3 of Table 5), while such patterns are not found for small firms (Columns 2 and 4). The symmetric magnitude and the opposite signs of γ_2 and γ_3 imply that large firms have the strongest investment incentives for swing counties.

5.3. **Alternative Explanations.** The voting behavior of residents in a county is not random, which may make it difficult to interpret our results in Table 3 as empirical evidence of our theory. Specifically, there may be unobserved county attributes, represented as ϵ_{ct} in (7), that are correlated with both the Democratic vote share and the broadband investment. Note that 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). Perhaps, 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. 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). 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 non-monotonic, concave relationship is not observed for small firms (Columns 2 and 4 in Table 5).

Another alternative explanation is that broadband investment is a *quid pro quo* to politicians. This angle has been studied in the empirical context of firm choice in employment (Carvalho, 2014; Bertrand et al., 2018), bank credits (Delatte et al.,

Table 5. Heterogeneous Response to Politics vs. Policy by Firm Size

	Investment in (log) number of blocks†			
	Any		≥ 25 Mbps	
	(1) Large	(2) Small	(3) Large	(4) Small
Pro-investment policy	-0.085	0.236**	-0.025	0.127
	(0.261)	(0.093)	(0.220)	(0.101)
Democratic vote share	2.463***	0.533	2.099**	-0.179
	(0.936)	(0.616)	(1.004)	(0.785)
(Democratic vote share)^2	-2.188**	-0.630	-1.672*	-0.116
	(0.935)	(0.676)	(0.952)	(0.865)
County and state attributes††	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Mean of the dependent variable	1.668	1.351	1.594	1.195
Number of firms	83	1,621	83	1,621
Number of observations	248,227	196,893	248,227	196,893

Notes: This table presents the 2SLS results. Large firms are ISPs that provided services in, on average, more than 5% Census Blocks within in a state during the data span, and the rest are referred to as a small firm. As a large firm can be considered as a potential entrant to every county in the state, Columns (1) and (3) include all counties within every state, despite that sometimes the firm has yet to provide any services in some counties. A small firm is considered as a potential entrant to the county with its presence during the period of our study. If a firm does not report its capacity in a period, we impute an interpolated value using reported data in adjacent years. Standard errors are adjusted for clustering within firms, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**) and 10% (*) levels. The instrumental variables include the lame duck indicator, vote margins, the interaction between these two variables. †: The outcome variable is the logarithm of the (population-weighted) number of blocks with investment plus one, so that we include observations with no investment. †† : The (time-varying) county attributes are listed in Table A1 and we also include state-level variables that represent the political environment such as the party of the governor and the legislature.

2022), and subsidiary location (Bisbee and You, 2022). To the extent that firm investment, especially in electorally competitive areas, can help reelect the incumbent politicians, they may be willing to return that favor to firms, by reducing procompetitive policies. In some sense, this explanation is not inconsistent with our theory, let alone the empirical findings. The difference is how we rationalize why policymaking responds to broadband capacity in swing counties: politicians being accountable for swing voters to increase their vote shares vs. returning the favor to large firms.

However, our preliminary analysis suggests that the investment patterns for swing counties, as documented in Table 3, are more pronounced in years without elections, which seems to be at odds with this *quid pro quo* argument.

6. 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. We connect our theory to this empirical finding by interpreting that local political environment, associated with how electorally competitive a given location is in state-wide elections, affects the extent of such policy influence. We show evidence that state policies promoting broadband investment respond more to the level of broadband in the electorally competitive counties.

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 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 policy-making 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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Appendix A. County Attributes for Our Analyses

In our regression analyses, we include various time-varying attributes of a county, drawn from various data sources such as American Community Survey, to represent demographic and socioeconomic characteristics of the residents in the county, as well as their political tendency. These attributes are likely to be associated with the demand for broadband services and the costs of providing those services.

Appendix B. Supporting the Instrumental Variable Approach

We investigate the determinants of state-level broadband policies, focusing on governors' electoral circumstances. Controlling for time-varying state demographic attributes (population size, income, race, age, and education), year fixed effects, and linear state-specific year trend, we find that a governor is less likely to bring in a policy to accommodate the right-of-way, to introduce a tax incentives, to enact a new broadband funding or financing legislation, or to establish an office designated for promoting broadband investment, when he/she cannot be reelected due to the state term limit, relative to when he/she can. However, this difference gets smaller when the voter support for the governor in his most recent election is larger (Table A2). In column (5) of this table, we use the number of any above-mentioned pro-investment policy as the dependent variable. As shown in this column, the "lame duck" effects are substantial in magnitude. The average number of pro-brand policies across the time span is only about 1.5; the lame duck effects will take this number down by 0.4. This pattern is robust to many specifications, including using the dichotomous measure of voter support and using voter support in his first gubernatorial election.

These findings are similar to those of List and Sturm (2006), in the context of state-level environmental spending. Following List and Sturm (2006), the intuition behind our findings is that (1) incumbent governors may have distorted broadband policy during their first term in office in order to increase their reelection chances, but they are no longer incentivized to do so during their second term in office when the term limit is binding, and that (2) this incentive to build a reputation for more votes in the reelection would be small if the governor is likely to be reelected. List and Sturm (2006) also points out the "lame duck" effects are unlikely to occur in primary policies, as politicians may not want to bend major issues concerning their political ideology or policy agenda. As we show in Table A3, it is notable that the "lame duck effect" documented in Table A2 does not apply to the overall budget size,

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.

measured by the (direct) general expenditure (Columns (1) and (2) of Table A3) or assistance or subsidy expenditures (Column (3) of the same table).

Table A2. Do Electoral Incentives Matter in Broadband Policy?

	Right-of-Way Accom. (1)	Tax Incentives (2)	Any Grant (3)	Office (4)	All (5)
Lameduck	-0.262**	-0.053*	-0.080*	-0.248***	-0.433**
	(0.114)	(0.030)	(0.043)	(0.067)	(0.181)
Lameduck× Vote margins	0.010**	0.003**	0.004	0.011***	0.020***
	(0.005)	(0.001)	(0.003)	(0.003)	(0.007)
Vote margins	-0.003	-0.001	0.000	-0.001	-0.004
	(0.004)	(0.001)	(0.002)	(0.002)	(0.006)
Democratic Governor	0.226***	-0.010	-0.030	0.031	0.219**
	(0.079)	(0.025)	(0.038)	(0.043)	(0.090)
Divided Branch	-0.160	0.032	0.005	-0.084	-0.134
	(0.111)	(0.034)	(0.040)	(0.061)	(0.120)
Split Legislature	-0.180*	-0.030	0.037	0.085**	-0.156
	(0.097)	(0.039)	(0.066)	(0.041)	(0.100)
Competitive Legislature	0.070	-0.003	0.044	0.050	0.059
	(0.058)	(0.024)	(0.040)	(0.051)	(0.094)
Time-varying state attributes†	Y	Y	Y	Y	Y
State FE, Year FE	Y	Y	Y	Y	Y
State-specific time trend	Y	Y	Y	Y	Y
Observations	550	550	550	500	550
Adjusted R^2	0.750	0.673	0.641	0.630	0.811

Notes: 50 state × (11 years, 2009–2019, except that Broadband office data is not available for 2019). Standard errors are adjusted for clustering within states, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**), and 10% (*) levels. All specifications include year fixed effects, state-specific time trends and time-varying state attributes including population characteristics on age, gender and race compositions, income, work, education and more.

Table A3. No "Lame Duck" Effects in Major Policies

	Log Expenditure of the State Government		
	Direct General	General	Assistance/ Subsidies
	(1)	(2)	(3)
Lameduck	0.020	0.011	0.125*
	(0.018)	(0.014)	(0.073)
Lameduck× Vote Margins	-0.000	-0.000	-0.001
	(0.001)	(0.001)	(0.002)
Vote Margins	-0.000	-0.001	-0.002
	(0.001)	(0.001)	(0.002)
Democratic Governor	0.003	0.008	-0.020
	(0.009)	(0.009)	(0.038)
Divided Branch	-0.006	-0.006	-0.005
	(0.013)	(0.013)	(0.033)
Split Legislature	-0.004	-0.005	0.031
	(0.012)	(0.010)	(0.023)
Competitive Legislature d	-0.026**	-0.021*	-0.021
	(0.011)	(0.011)	(0.054)
Time-varying state attributes†	Y	Y	Y
State FE, Year FE	Y	Y	Y
State-specific time trend	Y	Y	Y
Adjusted R^2	0.773	0.711	0.633
Observations	500	500	500

Notes: 500 observations (50 state × 10 years, 2009–2018). Standard errors are adjusted for clustering within states, and are provided in parentheses. Asterisks indicate the statistical significance at the 1% (***), 5% (**), and 10% (*) levels. All specifics include year fixed effects, state-year time trends and time-varying state attributes included in Table A2.