Understanding Digital Inequality and the Role of Cooperatives

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ABSTRACT

This dissertation aims to further our understanding of digital inequality and the role of cooperatives in relation to investor-owned firms. Chapter 1 provides a brief motivation for studying cooperatives and an overview of the dissertation. Chapter 2 provides a brief background on digital inequality, including various technologies and their quality. This chapter also describes how investor-owned firms and cooperatives show opposite patterns in providing high-quality or high-tech services in disadvantaged communities, motivating further investigation of the role of cooperatives in providing high-quality services in marginalized communities. Chapter 3 examines the comparative advantage of cooperatives relative to investor-owned firms in Internet infrastructure provision. Infrastructure projects generate positive local externalities for the communities in which they are located. Because cooperatives can internalize these benefits, they may be willing to provide higher-quality infrastructure than investor-owned firms, especially in marginalized communities where the provision costs are high relative to revenue. I found that cooperatives are more likely to provide Internet in communities where investor-owned providers offer poor quality service; these effects are stronger in rural communities, communities with persistent poverty, and communities with high social cohesion. Chapter 4 compares investor-owned incumbents' competitive responses to cooperative entry versus investor-owned firm entry. Formed and operating under the principle of prioritizing member benefits to profits, a cooperative entrant will be a larger threat than an investor-owned entrant because cooperatives are not likely to share the mutual understanding with investor-owned incumbents (i.e., minimize competition and maximize profits). I found that incumbents are more likely to upgrade their technology to high-tech in response to cooperative entry than to

investor-owned firm entry. The effect is stronger in markets with a low level of competition, measured by only one or two high-tech providers, than in markets with intense competition, measured by more than two high-tech providers. Moreover, the effect is stronger for the big providers that cover many geographic markets across the United States than for small local providers that cover a limited number of local markets.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1.

INTRODUCTION

Cooperatives are firms owned by consumers, producers, and employees rather than investors,[1] and they play a critical role in the economy. There are approximately 30,000 cooperatives in diverse economic sectors[2] in the United States, which collectively own more than $3 trillion in assets and generate more than $500 billion in revenue, $25 billion in wages, and 2 million jobs. Some 350 million Americans hold memberships in cooperatives, which generate nearly $79 billion from patronage refunds and dividends (University of Wisconsin Center for Cooperatives, 2009).

Despite their significance, existing scholarship on management and organizations has given limited attention to cooperatives, generally focusing on the factors that make them successful (Boone & Özcan, 2014; Ingram & Simons, 2000; Simons & Ingram, 2003; Yue et al., 2013). The scholarship has paid little attention to a more fundamental question: Why do cooperatives exist in capitalist economies where the means of production are commonly owned by investors? An answer can be found in economics and law literature, which has sought to understand when and why cooperatives may be valuable. Mainly theoretically driven, such literature points to

[1] While investor-owned firms can be seen as cooperatives owned by investors (Hansmann, 1996, 2013), I use "cooperatives" to refer to enterprises owned by a group of people who are not investors to distinguish the alternative organizational form that is less prevalent (consumer-owned) from the more dominant organizational form (investor-owned).

[2] In 2009, the University of Wisconsin Center for Cooperatives (2009) identified 29,284 cooperatives in the United States: 3,463 cooperatives in commercial sales and marketing (farm supply and marketing, bio-fuels, grocery, arts and crafts, and other retail), 11,311 in social and public services (healthcare, childcare, housing, transportation, and education), 9,964 in financial services (credit unions, farm credit system, mutual insurance, and cooperative finance), and 4,546 in utilities (electric, telephones, and water).

two distinctive types of market failure. First, there are situations where investor-owned firms cannot capture community-level externalities (Luo & Kaul, 2019; Ostrom, 1990, 2010; Ostrom & Ostrom, 1971. Investor-owned firms may not supply or may undersupply goods and services, and community members would have an incentive to come together to act in the community's best interests. Second, there are situations where investor-owned firms enjoy substantial market power (e.g., monopoly, monopsony), and buyers and suppliers form cooperatives to provide effective competition or bargaining power and reclaim value (Asmussen et al., 2020; Galbraith, 1952; Sexton, 1990; Sexton & Sexton, 1987; Stiglitz, 2009).

In this dissertation, I examine both types of market failure and provide empirical evidence of how cooperatives overcome them in the context of digital inequality, social, and economic inequalities stemming from unequal access to broadband. This is a great setting to answer the above question for several reasons.

First, digital inequality is a serious social issue. Access to high-quality Internet provides a wide array of socioeconomic benefits to users and their communities, including improving educational outcomes (Agarwal & Day, 1998), boosting employment opportunities (Forman et al., 2012; Hjort & Poulsen, 2019; Kolko, 2012; Kuhn & Skuterud, 2004), and providing easier access to health care (Finkelstein et al., 2006). Second, as more Internet-providing cooperatives have formed and expanded their service areas across the United States, incumbent investor-owned firms face increasing competition from new alternative Internet service providers (ISPs)—namely, cooperatives. This provides a great setting to investigate the relationship between cooperative entry and the service quality of incumbent investor-owned providers. The setting also allows for comparing the reactions of incumbent ISPs when cooperatives versus investor-owned firms enter their markets.

Third, because broadband services are geographically bounded, geographic markets are a relatively accurate boundary to define the availability of service options for consumers and the intensity of competition among providers (i.e., consumers usually do not travel to use broadband service, and broadband service providers covering distant areas do not directly compete). Fourth, the Federal Communications Commission (FCC) has strictly enforced mandatory filing on almost every ISP[3] in the United States since 2014 to closely evaluate Internet deployment. These regulations generate population data, which eliminates potential sampling bias. Fifth, Internet services are relatively uniform and vary mainly in quality, allowing for comparison of service quality and measurement of quality improvements.

The rest of the dissertation is organized as follows. Chapter 2 provides a brief background on digital inequality and alternative ISPs, municipal government, and cooperatives. Chapter 3 examines the comparative advantage of cooperatives relative to investor-owned firms in Internet infrastructure provision. Chapter 4 investigates investor-owned incumbents' competitive responses to cooperative entry compared to investor-owned firm entry. Chapter 5 concludes the dissertation. The followings are overviews of each chapter.

Chapter 2: Digital Inequality – Communities Left Out of Modern Innovations in Internet Infrastructure

This chapter provides a brief background on digital inequality. There have been multiple innovations in Internet technologies, from dial-up to fiber-to-the-end-user. High-tech or modern innovations diffused primarily in high-income and urban areas as profit-maximizing investor-owned firms have been the dominant ISPs. In

[3] All facilities-based ISPs are required to file FCC Form 477 biannually (June and December) at the census block level if their service speed exceeds 0.2 megabits per second (Mbps). The 0.2 Mbps threshold is a very slow speed, given that checking email or browsing the web requires a minimum of 1–5 Mbps, which means the FCC collects data if there is any Internet connection.

other words, upgrading to high-tech or modern technology is costly, so ISPs have largely ignored disadvantaged communities not deemed profitable. As a result, people in marginalized communities are left behind as our daily lives move online (e.g., online classes, telehealth, telework, job search, social media, online shopping). As 99.85% of all census tracts in the United States are covered by at least one ISP,[4] whether having Internet access or not is no longer a significant issue. Instead, the current issue is whether the *quality* of Internet service can support our increasingly Internet-dependent lives.

This chapter also briefly explains that the two alternative ISPs—municipal governments and cooperatives—are subject to different laws and regulations, limiting the ability of municipal governments to provide Internet services in many parts of the country. Besides the different laws and regulations, municipal governments are not viable options for many marginalized communities because their local governments lack enough resources to provide community-wide Internet service, leaving community members to turn to another alternative provider, cooperatives. Descriptive statistics illustrate that cooperatives show opposite patterns in providing high-quality or high-tech services in disadvantaged communities compared to investor-owned firms. Such descriptions motivate further investigation of the role of cooperatives in providing high-quality services compared to investor-owned incumbents and how their entry affects investor-owned incumbents. The following two chapters strive to answer these questions, respectively.

Chapter 3: Desert Places: Cooperatives as Infrastructure Providers in Marginalized Areas

[4] This percentage is based on FCC fixed broadband data from 2014 to 2018, covering all 50 states and Washington, D.C.

This chapter extends the comparative governance approach to study the conditions under which different institutional arrangements best deal with activities involving the public interest (Lazzarini, 2020; Luo & Kaul, 2019; Kaul & Luo, 2018; Klein et al., 2019). It asks the following questions: (1) What are the optimal governance forms for the provision of Internet infrastructure, and (2) under what conditions are these different forms most likely to prevail (Ostrom et al., 1993)?

I contend that infrastructure services have toll good and public good characteristics (Buchanan, 1965; Ostrom, 2010). While some of the benefits from infrastructure provision are private to those who use it, others are public in that they impact the entire community. Such locally bounded externalities indicate that a local cooperative can be the comparatively efficient governance form for infrastructure projects because its members can internalize the community benefits from the infrastructure in a way that investor-owned firms cannot (Luo & Kaul, 2019).

This chapter theorizes that cooperatives will be willing to provide higher-quality infrastructure than investor-owned providers in rural or low-income areas where the private benefits of infrastructure provision are insufficient to cover the direct financial costs. I expect that cooperatives are more likely to enter communities with greater social cohesion because they may be better able to organize for their collective good. Using the data on broadband provision in the United States, I find that cooperatives are more likely to provide Internet in communities where investor-owned providers offer poor-quality service. The results were consistent when using only high-tech Internet service. Moreover, these effects are stronger in rural communities, communities with persistent poverty, and communities with high social cohesion.

Chapter 4: Cooperatives as Entrants and Incumbents' Technology Upgrades

This chapter compares investor-owned incumbents' competitive responses to cooperative entry and investor-owned firm entry. Formed and operating under the principle of prioritizing member benefits to profits, cooperative entrants pose a greater threat than investor-owned entrants because cooperatives are not likely to share a mutual understanding with investor-owned incumbents (i.e., minimizing competition and maximizing profits). I find that incumbents are more likely to upgrade to high-tech technology tech in response to cooperative entry than to investor-owned firm entry. Moreover, the effect is stronger in markets with a low level of competition, measured by only one or two high-tech providers, than in markets with intense competition, measured by more than two high-tech providers. Moreover, the effect is stronger for the big providers that cover many geographic markets across the United States than for small local providers that cover a limited number of local markets.

The findings of this dissertation illustrate that cooperatives play critical roles in bridging the digital divide directly and indirectly. Cooperatives directly help close the digital divide by providing high-quality services in areas where investor-owned firms provide only poor-quality Internet services. They indirectly reduce digital inequality by competing with investor-owned incumbents and driving them to behave more competitively (upgrade to high-tech) than investor-owned entrants.

These findings contribute to the prior literature on public-private interaction (Cabral et al., 2019; Lazzarini, 2020), cooperatives (Boone & Özcan, 2014; 2016; Ingram & Simons, 2000; Schneiberg et al., 2008), comparative governance (Kaul & Luo, 2018; Klein et al., 2019; Lazzarini, 2020; Luo & Kaul, 2019), and competition among heterogeneous organizational forms (Casadesus-Masanell & Ghemawat, 2006; Chatterji et al., 2020; Wang & Shaver, 2014, 2016). They also contribute to public policy. The provision and maintenance of high-quality infrastructure, especially in disadvantaged areas, is the main concern for policymakers. Moreover, digital inequality has received recent attention in academia (DiMaggio et al., 2001; DiMaggio et al., 2004; Greenstein, 2019; Greenstein & Prince, 2006; Skiti, 2020b) and the popular media (Ali, 2019; Halpern, 2019). While debates on who can better solve the issue of digital inequality—or, more broadly, provide and maintain high-quality infrastructure—have been shaped mainly as central government versus privatization, this dissertation points to an alternative solution: cooperatives.

CHAPTER 2.

DIGITAL INEQUALITY

2.1. The Definition of High-Quality Internet

As 99.85% of all census tracts in the United States are covered by at least one ISP,[5] whether consumers have Internet access is no longer a significant issue. Instead, the primary issue is whether the *quality* of service can support our increasingly Internet-dependent lives (e.g., attending school online, working from home, using telemedicine, enjoying streaming services). Therefore, the current discussion focuses on broadband—the transmission of wide-bandwidth data over a high-speed Internet connection. The FCC has updated the benchmark for broadband speed as Internet deployment technologies advance and an online presence becomes increasingly integral to our lives: 200 kilobits per second (Kbps) download / 200 Kbps upload in 1996, 4 Mbps download / 1 Mbps upload in 2010, and 25 Mbps download / 3 Mbps upload in 2015.

While the FCC is supposed to update its broadband definition in a timely manner by studying the growing demand for bandwidth, the agency has been criticized for not keeping pace with technology advancements and consumer expectations (e.g., Brodkin, 2022; Falcon, 2020).[6] Due to the controversially subjective characteristics of the broadband definition set by the FCC, this dissertation defines high-quality Internet service based on the most advanced technologies that

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[5] This is based on FCC fixed broadband data from 2014 to 2018, covering 50 states and Washington D.C.

[6] The FCC is incentivized to report that more people have broadband access by setting a low standard because if the agency finds that such advanced technology is not being deployed to all Americans in a reasonable and timely fashion, it is obliged to take "immediate action to accelerate deployment" of advanced telecommunication technology by "removing barriers to infrastructure investment and by promoting competition" (Telecommunications Act of 1996, § 706).[6]

can provide the highest speeds based on the data collected by the FCC, rather than following the standard set by the FCC.

2.2. Innovations In Last-Mile Technologies

Before discussing digital inequality, it is necessary to understand the technologies that deliver connectivity to end users. The "last mile" refers to the final portion of the network between ISPs and retail customers. While the "backbone," "middle-mile," or the "trunk" parts of tree-like Internet networks mainly consist of fiber optic lines that can support high-speed Internet services, the "last-mile" is the bottleneck in networks because the technology used for this part limits the bandwidth that will be delivered to the end-users. The "last-mile" networks are the most numerous and costliest parts to upgrade (Bock et al., 2015). This dissertation covers these last-mile networks.[7]

2.2.1. Dial-up Internet

Dial-up Internet was developed in 1979 and first offered commercially in 1992 by Sprint in the United States. It was the first Internet service consumers could use because the technology utilized the existing telephone networks and did not require additional infrastructure. The technology can only provide up to 56 Kbps or 0.056 Mbps (Bock et al., 2015). As checking email or browsing the web requires a minimum of 1–5 Mbps, dial-up Internet cannot be used for modern websites and Internet applications in a practical sense.

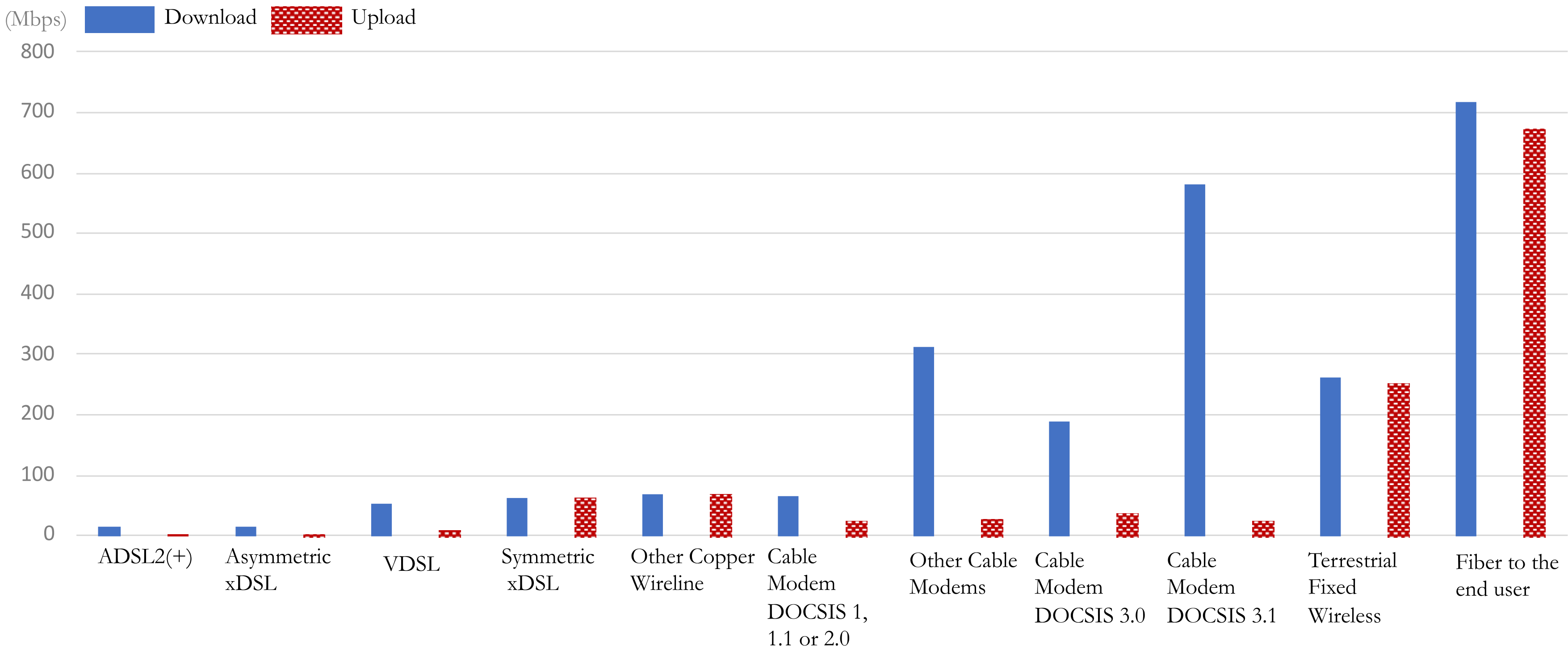
[7] Discussions on Internet technologies not considered broadband or fixed networks (mobile and satellite Internet) can be found in the appendices.

Table 1. Average Speeds by Technology and Distribution

Technology Type	Mean speed (Mbps)		%
ADSL2, ADSL2+	14.54	down	12.41%
	2.02	up	
Asymmetric xDSL	14.64	down	15.15%
	3.50	up	
VDSL	54.15	down	8.09%
	8.43	up	
Symmetric xDSL	61.34	down	0.81%
	61.30	up	
Other Copper Wireline	69.69	down	2.60%
	68.17	up	
Cable Modem – DOCSIS 1, 1.1 or 2.0	66.93	down	0.64%
	25.32	up	
Cable Modem other than DOCSIS 1, 1.1, 2.0, 3.0, or 3.1	311.80	down	0.35%
	26.03	up	
Cable Modem – DOCSIS 3.0	190.40	down	16.88%
	38.13	up	
Cable Modem – DOCSIS 3.1	579.97	down	4.95%
	25.71	up	
Terrestrial Fixed Wireless	262.32	down	26.92%
	251.68	up	
Optical Carrier / Fiber to the end user	718.62	down	11.16%
	673.72	up	

Note. Generated using FCC data from 2014 to 2018. Other technology accounting for 0.03% is not included. In my main analyses, I classify terrestrial wireless and fiber-to-the-end-user as high-tech because they provide significantly higher symmetrical speeds than other technologies. I define high-tech as fiber-to-the-end-user only for supplementary analysis because the technology provides the highest asymmetrical download and upload speeds.

Figure 1. Average Speeds by Technology



Note. Generated using FCC data from 2014 to 2018. Other technology accounting for 0.03% is not included. In my main analyses, I classify terrestrial wireless and fiber-to-the-end-user as high-tech because they provide significantly higher symmetrical speeds than other technologies. In addition, I define high-tech as fiber-to-the-end-user only for supplementary analysis because the technology provides the highest asymmetrical download and upload speeds.

2.2.2. Digital Subscriber Line (DSL)

Digital subscriber line was the next significant innovation in Internet technology after dial-up. Like dial-up, DSL transmits digital data over local telephone lines. However, DSL can send digital data simultaneously with telephone services because it uses higher frequency bands for data than voice data. While its speeds are better than dial-up, DSL is considered low-quality Internet technology according to current standards. Asymmetric DSL can provide download speeds up to 8 Mbps and upload speeds up to 384 Kbps; very high bitrate DSL can deliver downstream speeds up to 52 Mbps and upstream speeds up to 2.3 Mbps; and symmetric DSL provides higher and equal downstream and upstream transmission speeds than other DSLs (Mitchell, 2021).

2.2.3. Cable

Whereas DSL utilizes the telephone networks, cable Internet uses the cable television telecommunications infrastructure. Cable Internet access requires a cable modem at the end user's location and a cable modem termination system at the cable operator's facility. These two points are connected over coaxial (copper) cables. Most cable modems subscribe to the Data Over Cable Service Interface Specifications (DOCSIS), a globally recognized telecommunications standard that allows high-bandwidth data transfer over coaxial cable.

While DOCSIS has undergone several innovations to improve its speeds, cable Internet cannot compete with fiber-to-the-end-user, the latter of which provides much higher symmetrical upload and download speeds. Cable Internet's upload speeds have remained only a fraction of its download speeds, and such limitation is further overwhelmed by rapidly growing upstream traffic. The most current modem, DOCIS 3.1, released in 2013 and updated in 2017, theoretically allows up to 10 gigabits per second (Gbps) download / 1 Gbps upload. However, there has been criticism that the actual speeds never came close to these numbers, currently ranging from 3 to 35 Mbps upload (Brodkin, 2021a). Similarly, the FCC data from 2014 to 2018 shows that the average maximum speeds for DOCIS 3.1 are 580 Mbps download / 25.7 Mbps upload.

2.2.4. Fiber-to-the-End-User

Fiber-to-the-end-user or fiber-to-the-home connects the last mile via pulses of light through an optical fiber, a strand of glass or plastic, usually bundled together. A fiber optic cable generally permits about 10,000 times more bandwidth than a coaxial cable. It is much less susceptible to interference and noise than coaxial cables or wireless connections because beams of light do not interfere with electromagnetic waves (Bock et al., 2015; Cyphers, 2019). Due to such advantages, fiber-to-the-end-user is considered the gold standard in Internet infrastructure. While the current fiber-to-the-end-user typically can provide symmetrical upload and download speeds up to 1 Gbps, fiber technology has great potential and is considered "future proof." The maximum realized speed in a lab test was 125 petabits per second or 125 million Gbps (Alcatel-Lucent, 2009).

2.2.5. Terrestrial Fixed Wireless

Fixed wireless connects the middle mile and an end user via radio waves from an access point, usually the top of a tower, to an end user's reception device. Similar to fiber-to-the-end-user, fixed wireless can also support synchronous bandwidth speeds, which means its upload speeds match download speeds. Fixed wireless should not be confused with mobile coverage. While mobile coverage allows any device to connect within a giant Wi-Fi bubble broadcasted from towers, fixed wireless operates like an invisible wire, connecting two endpoints located at a relatively close distance.

2.3 Digital Inequality and Alternative Internet Service Providers

2.3.1. Digital Inequality — Communities Left Out of Modern Innovation

The last-mile technologies have undergone numerous innovations, from dial-up to fiber-to-the-end-user, to bring as fast an Internet connection as possible (see Figure 1). However, as Table 1 indicates, only a relatively small portion of the United States is benefitting from modern innovations that offer high-speed Internet, such as fiber-to-the-end-user (11.16%) and terrestrial fixed wireless (26.92%). Many Americans are stuck with old technologies, such as DSL. As more daily activities move online, requiring high-quality Internet access, people without access to high-quality Internet are increasingly left behind. The detrimental impacts of digital inequality (the digital divide) have been reported in media outlets (e.g., Holder, 2018; McLaughlin, 2016) and discussed by scholars (Augereau & Greenstein, 2001; DiMaggio et al., 2001; DiMaggio et al., 2004; Greenstein, 2019; Greenstein & Prince, 2006; Skiti, 2020b).

2.3.2. Alternative Internet Service Providers

As digital inequality has worsened, alternative ISPs—municipal governments and cooperatives—have started providing Internet service across the United States (see Figures 2a and 2b). After manually searching each ISP in the FCC data from 2014 to 2018 and triangulating various cooperative databases and provider websites, I identified 2,044 unique investor-owned providers, 327 cooperatives, and 154 municipal government providers. In this section, I briefly discuss how municipal governments and cooperatives are subject to different laws and regulations and how cooperatives can be the last resort for marginalized communities.

2.3.2.1. Municipal Governments

Proponents of municipal broadband provision argue that government intervention is necessary because a local government can provide high-quality Internet service at a reasonable price to its constituents and a discounted price to low-income residents. Opponents contend that government intervention puts private sector players at a competitive disadvantage because municipal governments can utilize direct taxpayer subsidies or government bonds at below-market interest rates. Despite these criticisms, many cities have successfully deployed citywide broadband, such as Vernon (CA), Longmont (CO), Dalton (GA), Lafayette (LA), Monticello (MN) (The Executive Office of the President, 2015).[8]

However, multiple states ban or restrict municipal broadband service across the United States, so it is not a viable solution in many areas. Moreover, as the recent federal case *Tennessee v. FCC* (2016)[9] shows, attempts by municipal governments to expand service beyond their territorial boundaries can be blocked. The implication is that the role of municipal government in providing broadband is severely limited even in the states that allow it. Furthermore, as opponents of municipal broadband provision keep striving to ban local governments from providing Internet service (Brodkin, 2021b), such uncertainty discourages local governments from initiating or expanding their services.

Another limitation of municipal provision is that local governments in marginalized communities lack enough resources to provide community-wide networks like those in larger cities with a high population density or high-income

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[8] Accessed at https://files.eric.ed.gov/fulltext/ED584128.pdf

[9] The Sixth Circuit Court of Appeals rejected the FCC's authority to override Tennessee and North Carolina state laws that limited the expansion of municipal broadband Internet service beyond the cities of Chattanooga (TN) and Wilson (NC).

population. As a result, marginalized communities often turn to an alternative solution: a cooperative.

2.3.2.2. Cooperatives

A cooperative is "a user-owned and controlled business from which benefits are derived and distributed equitably on the basis of use or as a business owned and controlled by the people who use its services" (USDA, 2011). Even though investors do not own cooperatives, they are considered business entities (most cooperatives are incorporated under state law). They thus are not subject to the laws and regulations that often challenge municipal government providers. Moreover, the Telecommunications Act of 1996, the first major change of telecommunications law in decades to increase competition, made it clear that any communications business can compete in any market. Therefore, forming cooperatives may be the best way to meet the needs of people in marginalized communities where investor-owned firms underserve.

As previously discussed, municipal provision is not even a viable option for people in marginalized communities with local governments that lack resources. Even communities with capable municipal governments may face legal challenges in initiating or expanding broadband provision due to hostile environments against municipal providers. Therefore, in this dissertation, I focus on the role of cooperatives, a viable alternative for communities left out by profit-maximizing firms and unable to depend on their municipal governments.

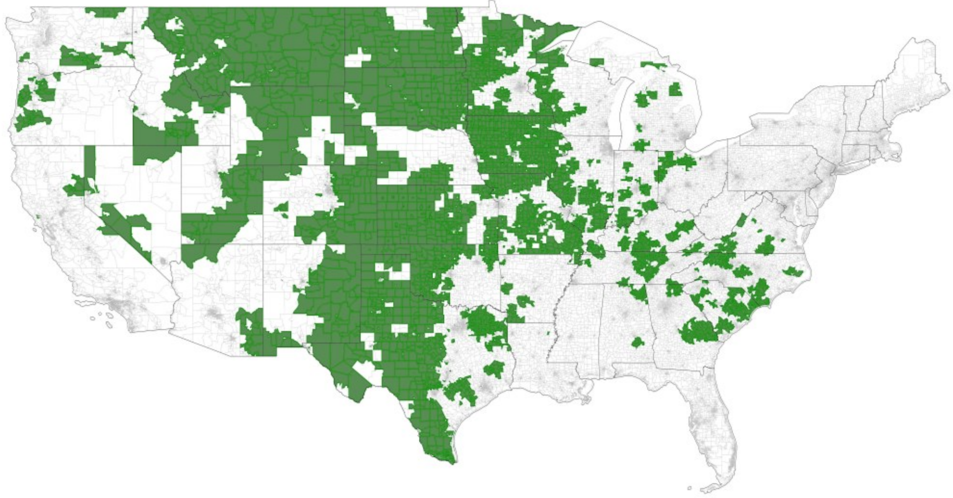
Furthermore, descriptive statistics show that cooperatives have distinctively opposite patterns from investor-owned firms and municipal governments in providing service, further motivating the investigation of the role of cooperatives. Table 2a shows that investor-owned firms are still the dominant ISPs, but they provide more high-tech Internet services in high-income and urban areas than in low-income and rural areas. In contrast, while their coverage is much smaller than investor-owned firms, cooperatives provide more high-tech Internet services in low-income and rural areas than in high-income and urban areas. Municipal government providers do not show a sizable gap between coverage areas in high-income versus low-income areas and urban versus rural areas.

Similar patterns can be found by using speeds as a measure. Table 2b shows that investor-owned providers offer much higher speeds in high-income and urban areas than in low-income and rural areas. In contrast, cooperatives provide much faster Internet service in low-income and rural areas than in high-income and urban areas.

These interesting patterns motivate systematic investigations on the role of cooperatives in bridging the digital divide. What drives cooperatives to show different patterns from investor-owned firms in providing high-quality Internet services? What are the impacts of having such a different type of competitor (cooperatives) for investor-owned incumbents? Do incumbents react differently when faced with investor-owned competitors?

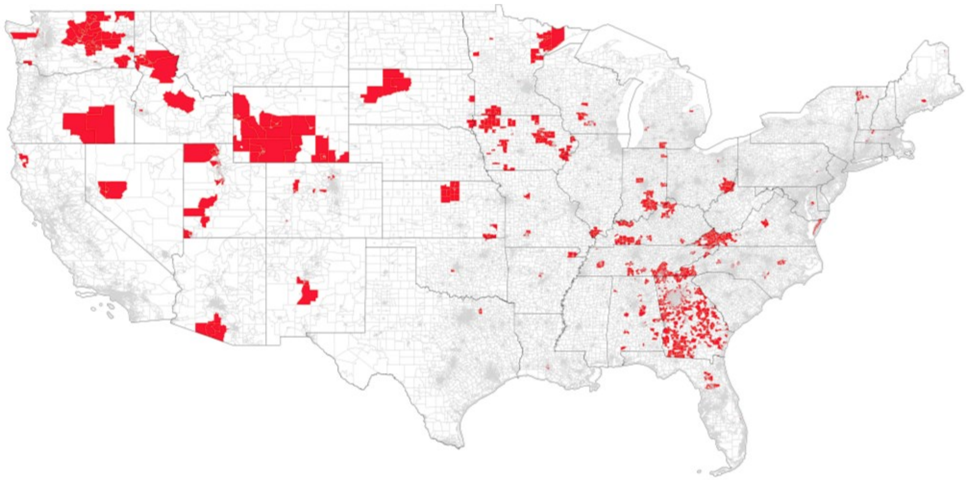
In the next chapter, I ask under what conditions cooperatives are more likely to enter than investor-owned firms. In Chapter 3, I investigate the investor-owned incumbents' competitive responses to the entry of cooperatives, specifically asking, is cooperative entry more likely to drive competitive responses from incumbents than investor-owned firm entry? If so, under what conditions?

Figure 2a. Census Tracts Where Cooperatives Provide Internet Service



Note. Generated using QGIS with December 2017 FCC broadband availability data (aggregated at census tract level).

Figure 2b. Census Tracts Where Municipal Governments Provide Internet Service



Note. Generated using QGIS with December 2017 FCC broadband availability data (aggregated at census tract level).

Table 2a. Broadband Coverage by Organizational Form

	Investor-owned		Cooperatives		Muni. gov.		Total
	All	High tech	All	High tech	All	High tech	census tracts
High-income	99.90%	92.61%	5.65%	5.02%	2.53%	2.12%	142,664
Low-income	99.81%	86.56%	9.94%	8.71%	3.98%	2.96%	142,656
Urban	100.00%	91.56%	2.06%	1.89%	2.20%	1.87%	177,746
Rural	99.61%	86.32%	17.27%	15.09%	5.00%	3.65%	107,574
High-ethnic diversity	99.94%	90.86%	4.32%	3.74%	2.91%	1.89%	142,659
Low-ethnic diversity	99.77%	88.31%	11.27%	9.99%	3.60%	3.19%	142,661
High-immigration	99.94%	91.53%	5.24%	4.69%	3.05%	2.37%	138,475
Low-immigration	99.77%	87.75%	10.20%	8.92%	3.45%	2.70%	146,845
Total	99.85%	89.59%	7.79%	6.87%	3.26%	2.54%	285,320

Note. Table shows Internet coverage by organizational form at the census tract level. Specifically, the cells report for each subsample, the percentage of census tracts with any tech type of Internet coverage (All), and high-tech Internet coverage (High tech) by at least one provider of the focal organizational form. High tech is defined as terrestrial wireless and fiber-to-the-end-user (see Table 1 and Figure 1).

Table 2b. Broadband Speed by Organizational Form

	Investor-owned	Cooperative	Muni.gov.
High-income	115.68	122.60	401.27
Low-income	85.24	161.72	323.77
Urban	114.25	107.55	479.37
Rural	77.61	155.39	262.75
High-ethnic diversity	105.80	125.10	333.50
Low-ethnic diversity	95.13	156.13	370.46
High-immigration	109.66	130.11	400.02
Low-immigration	91.79	155.96	315.50
All	100.47	147.53	353.93

Note. Table shows the quality of broadband coverage by organizational forms at the census tract level. Specifically, the cells report for each subsample the average upload speed (in Mbps) provided by the focal organizational form.

CHAPTER 3.
DESERT PLACES: COOPERATIVES AS INFRASTRUCTURE PROVIDERS IN MARGINALIZED AREAS

"I think that is the main reason cooperatives have continued to expand their broadband offerings; their local communities are turning to them to provide what the for-profit companies won't."

- Corby Erwin, Plumas-Sierra Telecommunications[10]

3.1. Introduction

The intersection of public and private interests is an area of growing interest in strategy research (Cabral et al., 2019; Mahoney et al., 2009). Some studies have focused on the role of investor-owned firms in addressing grand challenges and solving social issues (Ballesteros et al., 2017; George et al., 2016; Vakili & McGahan, 2016), including through public-private partnerships (Kivleniece & Quelin, 2012; Bruce et al., 2019; Quelin et al., 2019; Rangan et al., 2006). Others have looked to alternative organizational arrangements, such as nonprofits (Chatain & Plaksenkova, 2019; Hwang & Powell, 2009), social enterprises (Dacin et al., 2011; Santos, 2012; Zahra et al., 2009), cooperatives (Boone & Özcan, 2014, 2016; Ingram & Simons, 2000; Yue et al., 2013), community benefit agreements (Dorobantu & Odziemkowska, 2017), and other hybrid forms (Battilana & Lee, 2014; Fosfuri et al., 2016; Luo & Kaul, 2019). This myriad of organizational forms has, in turn, led scholars to advocate a comparative governance approach to study the conditions

[10] Private communication with the author, dated May 9, 2019

under which different institutional arrangements best deal with activities involving the public interest (Kaul & Luo, 2018; Klein et al., 2019; Lazzarini, 2019; Luo & Kaul, 2019).

In this study, I extend this comparative governance approach to the context of infrastructure provision, asking the following questions: (1) What are the optimal governance forms for the provision of infrastructure, and (2) under what conditions are these different forms most likely to prevail (Ostrom et al., 1993)? I contend that infrastructure services have toll good and public good characteristics (Buchanan, 1965; Ostrom, 2010). While some of the benefits from infrastructure provision are private (and therefore excludable) to those who use it, others are public (and therefore nonexcludable) in that they impact the entire community. The presence of these locally bounded externalities means that, in some cases, the comparatively efficient governance form for infrastructure projects will be a local cooperative because its members can internalize the nonexcludable benefits from infrastructure provision in a way that investor-owned providers cannot (Luo & Kaul, 2019). Specifically, I theorize that cooperatives will be willing to provide higher-quality infrastructure than investor-owned providers in rural or low-income areas where the private benefits of infrastructure provision are insufficient to cover costs. I also expect cooperatives to be more successful in communities with greater social cohesion because they may be better able to organize for their collective good.

As previously discussed, I test these arguments in the context of broadband provision in the United States. Uniquely detailed data from the FCC allows for tracking Internet provision at the census tract level from 2014 to 2017, including the identity of ISPs, the technology used, and the listed speed of provision. I find that cooperatives are more likely to provide Internet in communities where investor-owned provision is slow or based on low-speed technologies (primarily DSL or cable). Consistent with my theory, this relationship is stronger in rural communities and communities with high social cohesion (as reflected in low ethnic fragmentation and low immigration rates), communities with moderate income levels, and communities with persistent poverty. These results are robust to the inclusion of census tract and year fixed effects and the use of a government policy (the Connect America Fund) that incentivized investor-owned providers to invest in underserved areas as an instrument. Moreover, supplementary analyses show that cooperative entry in response to low-quality investor-owned provision involves providing high-quality broadband services—measured by both the technologies used and the reported upload speeds—and that these results hold across both new and legacy cooperatives.

This study makes several contributions to the literature. By applying a comparative governance lens to infrastructure provision, this study extends existing theory on public-private interaction (Cabral et al., 2019; Lazzarini, 2019), showing how the relative balance of public and private benefits from an activity influences how it is best organized. In doing so, the study also contributes to research on the role of cooperatives, providing empirical support for recent theoretical work that stresses their ability to deal with locally bound externalities (Luo & Kaul, 2019) and offering additional insights into the conditions under which they are more likely to prove successful (Boone & Özcan, 2014; Yue et al., 2013).

Furthermore, this study has important implications for public policy. The provision and maintenance of high-quality infrastructure, especially in rural areas, is a central concern for policymakers. The specific issue of digital inequality between prosperous and marginal communities in the United States and elsewhere has received a great deal of recent attention both in academia (DiMaggio et al., 2001; DiMaggio et al., 2004; Greenstein, 2019; Greenstein & Prince, 2006; Skiti, 2020b) and the popular media[11] (Ali, 2019; Halpern, 2019). This study offers theoretically driven, systematic evidence for the role of cooperatives in helping to bridge this divide, emphasizing the potential for self-organized community action as a path to economic development.

3.2. Cooperatives as Infrastructure Providers

3.2.1. Private and Community Benefits of Infrastructure

In recent years, strategy scholarship has grown interested in studying the role of investor-owned firms and other private organizations in solving social problems (e.g., poverty, inequality, disease, pollution), thus helping to build a sustainable and inclusive global future (George et al., 2012; George et al., 2016; Mahoney & McGahan, 2007; Mahoney et al., 2009). While these grand challenges were traditionally considered the responsibility of the state (Pigou, 1920), scholars have come to realize these problems can be, and often are, solved through the collective action of private actors that organize and cooperate for their common good (Coase, 1974; Ostrom, 1990, 2010). This, in turn, suggests thinking of the solution to social issues as a governance problem, meaning a problem of finding the best institutional arrangement to address the issue efficiently and effectively (Coase, 1960; Klein et al., 2019; Lazzarini, 2019). It suggests using a discriminating alignment approach (Williamson, 1996), matching the attributes of a social issue to the comparatively efficient governance form to address it (Luo & Kaul, 2019).

In this study, I apply such a discriminating alignment approach to the problem of infrastructure provision. Infrastructure projects are typically thought of as toll goods or public goods (Buchanan, 1965; Ostrom, 2010; Ostrom & Ostrom, 1971);

[11] In June 2019, an entire episode of comedian Hasan Minhaj's Netflix series *Patriot Act* was devoted to the issue of broadband access. Available to view at: https://youtu.be/xw87-zP2VNA.

their benefits, though generally less subtractable,[12] are highly excludable. For example, a bridge or road does not get used up by the people driving on it, so one person's use does not prevent others from using it (low subtractability), but it is possible to monitor who uses the bridge or road and charge a fee for doing so (high excludability). This excludability of infrastructure (and of toll goods generally) means that society can rely on private actors to provide such goods because the ability to charge for access, coupled with the natural monopoly that comes from low subtractability, creates a profit potential. While some level of government intervention may be required to overcome demand uncertainty (Klein et al., 2013; Rangan et al., 2006), in general, toll goods can be, and are, provided by investor-owned enterprises.

However, the benefits produced by an infrastructure project are not fully excludable. Infrastructure projects produce not only direct benefits for those who access or use them but also indirect benefits for the communities in which they are located. For instance, access to better transportation through roads and bridges may promote economic development by creating new opportunities for business and exchange (Banerjee et al., 2012). Enhanced broadband access may provide several socioeconomic benefits to communities (Council of Economic Advisers, 2016; Seamans, 2018), such as improving educational outcomes (Agarwal & Day, 1998), boosting employment opportunities (Forman et al., 2012; Hjort & Poulsen, 2019; Kolko, 2012; Kuhn & Skuterud, 2004), and providing superior access to health care (Finkelstein et al., 2006).

[12] Early work in this area often spoke of goods whose use by one person precluded their use by another as rivalrous. In this paper, we follow Ostrom (Ostrom, 2010; Ostrom & Ostrom, 1971) and speak of such goods as having high subtractability. Infrastructure projects, while not generally subtractable, are subject to congestion (as anyone stuck in rush hour traffic can attest!), which is why we speak of them as low subtractability rather than as nonsubtractable.

The key point is that these indirect benefits accrue to everyone in the community and are not limited to those use of the infrastructure. People who never travel out of their city may still benefit from its greater connectivity; those who do not have a broadband connection may still benefit from neighborhood businesses having one. These indirect benefits of infrastructure are thus externalities (i.e., they are nonexcludable) albeit limited in scope to the local community (Coase, 1974; Ostrom, 1990). Infrastructure thus may be considered as partly a toll good (its direct benefits are excludable) and partly a public good (its indirect benefits are nonexcludable).

3.2.2. The Role of Cooperatives

The dual nature of infrastructure projects has implications for how they are best governed. While toll goods may be well administered by investor-owned firms, as already mentioned, cooperatives may better organize the provision of bounded externalities (Luo & Kaul, 2019). A cooperative is "a user-owned and controlled business from which benefits are derived and distributed equitably on the basis of use or as a business owned and controlled by the people who use its services" (USDA, 2011). Unlike investor-owned firms,[13] the residual rents of cooperatives are distributed among members rather than among investors. Control rights for the cooperative reside with the members, generally on a democratic (one-member, one-vote) basis (Hansmann, 1996; Hart & Moore, 1996, 1998).[14] Cooperatives are active in many areas of the economy (Boone & Özcan, 2014), including credit unions (Barron et al., 1994), retail cooperatives (Ingram & McEvily, 2007), and agricultural

[13] Comparing investor-owned firms and cooperatives does not mean that the latter are nonprofit. Most cooperatives are incorporated under state law as cooperative corporations rather than tax-exempt nonprofits. The key difference is that nonprofits are constrained from distributing their profits to individuals, whereas cooperatives can and do distribute profits to their members.
[14] Prior scholarship (Hansmann, 1996; Hart & Moore, 1998) has examined the benefits and costs of cooperative governance relative to investor ownership in the provision of private goods. I draw on this work but focus on comparative governance in the case of infrastructure provision.

cooperatives (Schneiberg et al., 2008). They frequently compete with investor-owned firms by offering similar products and services (Chatterji et al., 2020).

The key advantage of cooperatives in dealing with activities that produce bounded externalities is that they allow for private ordering (Ahuja & Yayavaram, 2011; Williamson, 1996), placing key organizational decisions in the hands of members of the local community who have both a superior understanding of the magnitude of these externalities and stronger incentives to be concerned with such externalities (Hansmann, 1996; Hart & Moore, 1996, 1998; Luo & Kaul, 2019). In simple terms, local cooperatives internalize the indirect benefits generated by the infrastructure project because those who benefit from these externalities are also the owners and—critically—the decision makers of the organization (Hansmann, 1996; Hart & Moore, 1996, 1998). The cooperative's members thus derive two benefits from the infrastructure project: the direct financial returns they receive as owners of the cooperative and the indirect benefits they receive as members of a community that sees enhanced economic opportunity from the project.[15] In contrast, the investor-owned firms' shareholders receive only the financial returns from the use of the infrastructure and do not share in the externalities it generates for the community; therefore, investor-owned firms may undersupply infrastructure relative to the social optimum.

These differences do not suggest that cooperatives always have an advantage in infrastructure projects. Successful collective action, such as that represented by cooperatives, is challenging to organize and maintain. Given the need for constant

[15] While government providers would also value externalities, they may be subject to other forms of government failure (Coase, 1964) and will often care about constituencies larger than a single community (Luo & Kaul, 2019; Olson, 1986). In the specific case of Internet provision, there may also be regulatory barriers to municipal provision (Skiti, 2020b). I focus my theory development on comparing investor-owned firms and cooperatives, though I empirically account for the role of municipal providers.

assurance and monitoring (Ostrom, 1990, 2005; Sen, 1967; Sugden, 1984), and the potential for internal conflict (Hart & Moore, 1998), the bureaucratic costs (Williamson, 1985) of cooperatives are likely to be higher than those of comparable investor-owned firms. Moreover, the relatively lower-powered incentives in cooperatives may limit the efficiency of their infrastructure provision relative to investor-owned firms (Luo & Kaul, 2019; Williamson, 1985). Finally, the local nature of cooperatives necessary to internalize the bounded externalities may also limit their scale relative to investor-owned providers, resulting in lost scale economies (Luo & Kaul, 2019). Overall, it is thus likely that the costs of infrastructure provision under a cooperative will be higher than those under a comparable investor-owned firm.

3.2.3. Comparative Governance of Infrastructure

Whether cooperatives or investor-owned firms are preferable infrastructure providers depends on the relative importance of the benefits to the local community from bounded externalities. The more important these community benefits, the greater the comparative advantage of cooperatives.

Figure 3a illustrates this point. It plots the average quality of infrastructure services provided to each user on the horizontal axis. The marginal cost of providing that quality to each user and the direct and total benefits of doing so is on the vertical axis. Lines MC_C and MC_F show the marginal increase in cost per user for a unit increase in infrastructure quality for cooperatives and investor-owned firms, respectively.

As discussed, I expect the costs of cooperative provision to be higher than comparable investor-owned firms, so $MC_C > MC_F$. I also assume that the cost per user increases with the infrastructure quality and does so at an increasing rate. The intuition is that as the provision quality increases, it becomes challenging to further increase quality, often requiring new innovations or substantial investments in state-of-the-art technologies. In the extreme, beyond a certain point, it is no longer possible to further increase infrastructure quality, and the marginal cost curve becomes vertical. In contrast, at low levels of quality, improving service is easy because there are plenty of “low-hanging fruit”: minor adjustments or basic improvements through which quality may be improved at a comparatively low cost.

The MR line shows the marginal increase in revenue per user for every unit increase in infrastructure quality. I assume that users have no inherent preferences for investor-owned firms or cooperatives. They care only about the infrastructure quality provided to them, so the marginal revenue line for both providers is the same. The MR line is clearly increasing in quality (users will pay more for higher-quality provision), and I assume, for simplicity, that it increases at a constant rate. The line MB plots the marginal increase in total benefits per user from infrastructure provision per unit increase in quality, meaning it plots the sum of the increase in revenue from users (which measures the direct benefits of infrastructure provisions) and the increase in the indirect benefits to the community as quality increases. The gap between the MR and MB lines thus reflects the externalities generated by infrastructure provision as a function of its quality.

Figure 3a: Investor-Owned versus Cooperative Infrastructure Provision

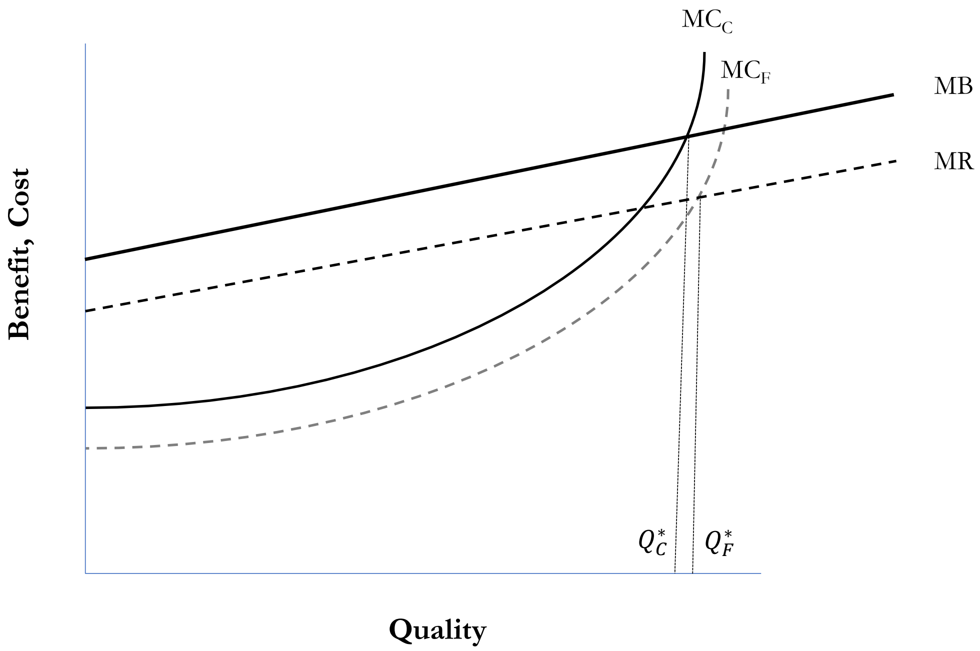


Figure 3a also shows the quality level chosen by each provider in equilibrium.[16] The investor-owned provider chooses quality level Q_F^* at the point where the MC_F line intersects the MR line from below. This is the quality level at which the profit per user is maximized. The cooperative provider chooses quality level Q_C^* at the point where the MC_C line intersects the MB line from below. This is the quality level at which the total benefit to the owners of the cooperative—including both the direct benefits from infrastructure use (paid for as revenue) and the (internalized) indirect benefits to the community, less the cost of provision—are maximized. The key point is that the cooperative internalizes the community benefit, making its quality decisions based on the overall benefits rather than just the direct (excludable) benefits.

[16] Note that I am not modeling competition between multiple providers; Figure 3a plots the quality level each provider would choose if it had a monopoly, consistent with the nonsubtractable nature of infrastructure provision. We may thus think of the figure as representing the *ex ante* choice of quality each provider would offer if asked to bid for access to the market (Demsetz, 1968).

In Figure 3a, $Q_F^* > Q_C^*$, means the investor-owned firm would choose a higher provision quality than the cooperative. In this case, the investor-owned firm is the comparatively advantaged governance form for infrastructure provision.[17]

Figures 3b–3d explore the factors that shift the comparative advantage of investor-owned firms relative to cooperatives in infrastructure provision. Figure 3b is similar to Figure 3a, except that the MR and MB curves are shifted downward because the average user has a lower willingness to pay for infrastructure provision relative to the average user in Figure 3a. As Figure 3b shows, the downward shift of the MR and MB lines causes the optimal quality levels chosen by both providers to decline (both providers will offer lower quality if users are not willing to pay as much), but the decline is greater for investor-owned firms than for cooperatives so that Q_C^* is now greater than Q_F^*.

In equilibrium, the cooperative provides a higher level of infrastructure quality than the investor-owned firm and is, therefore, the comparatively advantaged provider in this scenario. The intuition here is that as the direct benefits to users from infrastructure provision decline, factoring in the externalities generated becomes more critical to the choice of quality. Thus, the lower the user's willingness to pay for infrastructure, the greater the weight of the externalities in determining the comparatively efficient governance form, and the greater the likelihood that it will be a cooperative.

[17] Note that the first best outcome would be for the investor-owned firm to provide the quality level at which MC_F intersect MB, perhaps through the provision of a subsidy by a fully rational social planner. Ignore this hypothetical option here and limit consideration to the best among feasible alternatives (Luo & Kaul, 2019; Williamson, 1996).

Figure 3b: Moderating Effect of Willingness to Pay

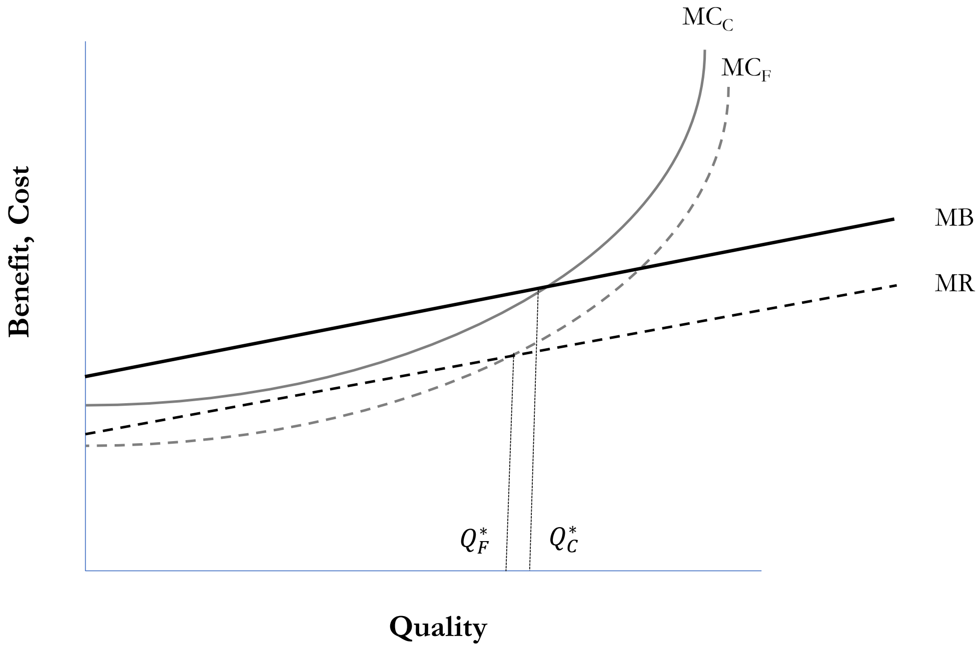


Figure 3c: Moderating Effect of Cost of Provision

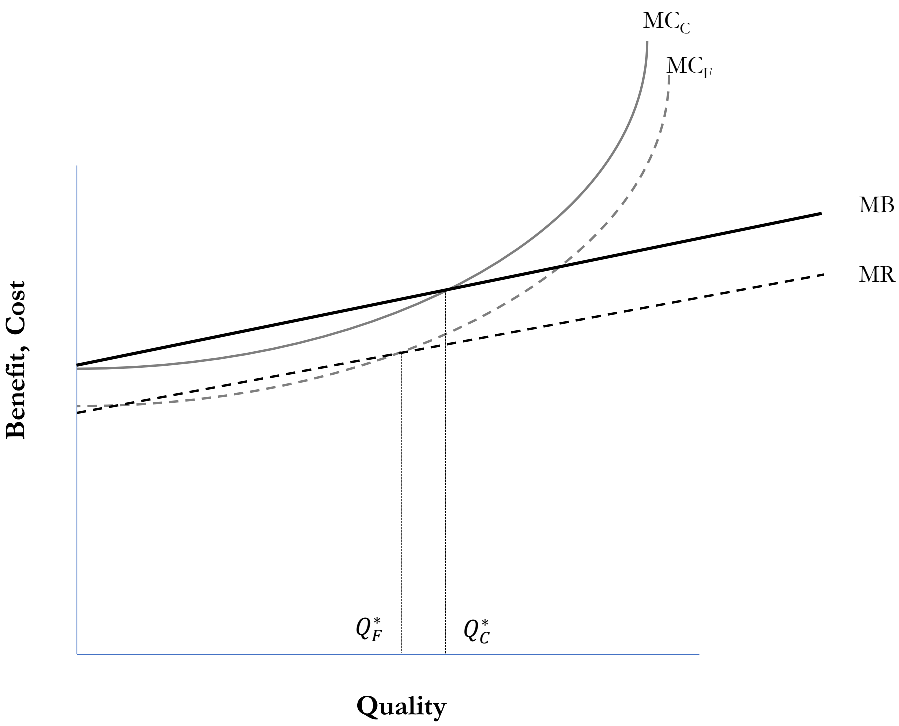


Figure 3d: Moderating Effect of Cost of Cooperative Governance

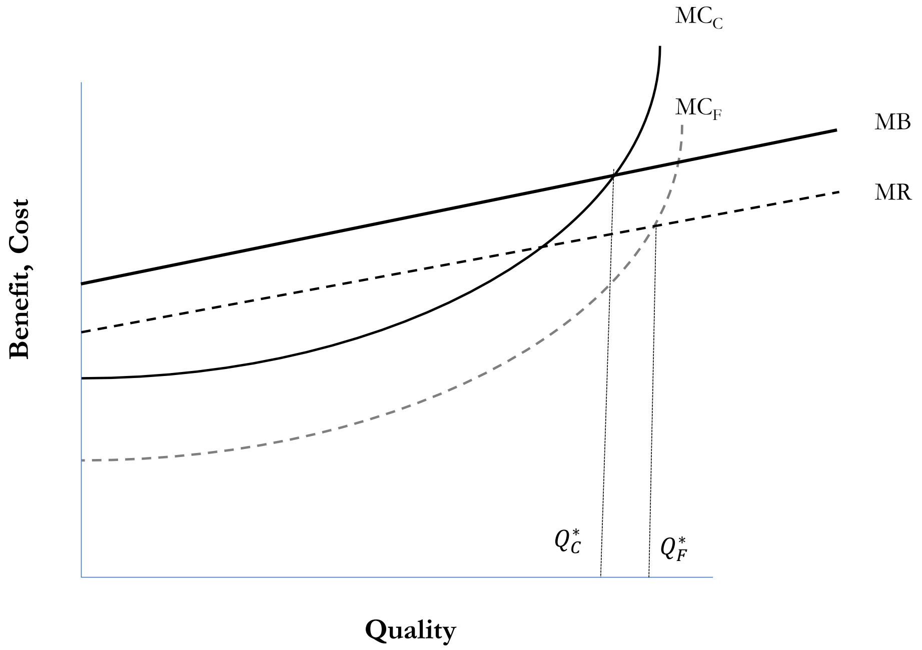


Figure 3c offers a similar argument, except, in this case, I keep the MB and MR curves as they were in Figure 3a but shift the cost curves upward. Once again, I see a drop in the equilibrium levels of quality chosen by both providers, but the decline is greater for investor-owned firms than for cooperatives, so that $Q_C^* > Q_F^*$, and cooperatives are now the comparatively advantaged providers.

The intuition for this case is very similar to Figure 3b: as the cost of infrastructure provision rises, it becomes harder to cover high-quality provision (or provision at all) out of user revenues alone. It thus becomes more important to consider the externalities generated when choosing a quality level. I, therefore, expect that as the cost of infrastructure provision (relative to the user's willingness to pay) rises, cooperatives will be increasingly likely to emerge as the comparatively advantaged providers.

While Figure 3c focuses on factors that raise the cost of infrastructure provision for both potential providers (e.g., physical or geographical conditions, technological barriers), Figure 3d considers factors that increase the costs of cooperatives relative to investor-owned firms. Successful cooperation may be easier to maintain where incentives between members are strongly aligned (Hansmann, 1996), when observability of other's actions is high (Holmstrom, 1979; Ostrom, 1990), and when members are embedded in networks of strong social ties (Dorobantu et al., 2017; Granovetter, 1985; Jones et al., 1997; Yenkey, 2015; Yue et al., 2013). Where these factors are absent—specifically, where cooperative members are heterogeneous in their interests or where the scope of the cooperative's activities is quite broad—the bureaucratic costs of cooperative governance are likely to be high (Hansmann, 1996; Hart & Moore, 1998), and cooperative governance may thus be relatively inefficient compared to investor-owned provision.

Figure 3d shows this case, shifting the MC_C line upward while keeping all else the same as in Figure 3a. Unsurprisingly, an increase in the relative inefficiency of cooperatives lowers the equilibrium quality of cooperative provision, increasing the gap between Q_F^* and Q_C^* and increasing the likelihood that investor-owned provision will be comparatively advantaged.

3.3. Broadband Provision

Having proposed a general theory of the comparative advantage of cooperatives versus investor-owned firms in infrastructure provision, I next develop specific hypotheses to empirically test the theory in the context of fixed broadband provision. I believe this is an excellent setting for several reasons.

First, the provision of broadband is a classic example of an infrastructure project involving large-scale investments in physical assets that are nonsubtractable and thus create natural barriers to entry, especially in the United States, where open access policies[18] are rare. The result is that most households have a choice of relatively few broadband providers (Greenstein, 2019; Wallsten & Mallahan, 2013), often no more than one[19] (Trostle & Mitchell, 2018). Second, broadband provision is a setting where several governance forms coexist. There is substantial provision by cooperatives[20] across most U.S. states and regions, as shown in Figure 2.

Third, Internet provision has the advantage that the speed of the connection is an unambiguous and universally accepted measure of broadband quality, making comparisons across geography and time easier. Fourth, Internet provision is closely monitored, allowing us to track detailed information about the number and identity of providers and the provision quality at a granular census block level (Skiti, 2020b). Such granularity is important because broadband provision—unlike dial-up access (Downes & Greenstein, 2002)—is tightly bound to the local geography. Studies have documented significant variance in provision quality, even within a city (Greenstein & Prince, 2006; Grubesic & Murray, 2002). Moreover, as discussed in Chapter 2, several technologies provide Internet connectivity, allowing us to distinguish between providers of differing quality.

Finally, as previously mentioned, the issue of digital inequality has received substantial attention in recent years (DiMaggio et al., 2001; DiMaggio et al., 2004). Scholars have emphasized broadband provision as a key driver of inequality in Internet access (Augereau & Greenstein, 2001; Greenstein, 2019; Greenstein & Prince, 2006; Skiti, 2020b). Broadband provision is linked to broader community

[18] Open access policies require existing carriers to lease access to their physical networks to their competitors at a regulated price and are widely used in many countries (e.g., Sweden, the Netherlands). In the United States, open access policies generally have not been adopted for fear they may weaken incumbent incentives to invest in new technologies (Benkler, 2010), though some municipal governments (e.g., Public Utility Districts in Washington state) have voluntarily adopted such policies.
[19] In my sample (described later), about 30% of census blocks in the country are served by only one investor-owned ISP.
[20] In my sample, cooperatives cover 7.79% of all census tracts in the United States, while municipal providers cover 3.26%.

level outcomes (Council of Economic Advisers, 2016; Hjort & Poulsen, 2019; Seamans, 2018), making it an important and timely topic of study.

To test my theory of the comparative advantage of cooperatives versus investor-owned firms in the context of Internet provision, I choose to focus on the presence of cooperatives. Because many communities in the United States are served by just one or two broadband providers I cannot simply compare the performance of cooperative and investor-owned providers within communities. Therefore, this study focuses on the question: Which markets do cooperative ISPs serve? Given the basic toll good nature of Internet provision, and the fact that almost every community in the United States receives at least some Internet provision by investor-owned firms, though often low quality, the investor-owned provision can be considered the baseline for Internet service. Cooperatives may only enter a community if they believe they can provide superior service compared to investor-owned firms (i.e., if they believe they have a comparative advantage in serving the community).

Building on the theoretical arguments in the previous subsection, the core prediction in this study is that cooperatives will be comparatively advantaged in providing broadband where the revenues for investor-owned firms are relatively low compared to their costs. In such communities, investor-owned firms will see little incentive to make the substantial investment in physical infrastructure required to provide high-speed broadband access (e.g., fiber) and may prefer to limit themselves to providing basic low-quality Internet service (e.g., DSL), if they provide service at all. In contrast, cooperatives will potentially internalize the externalities generated by higher speed broadband access in the local community, so they may be more willing to invest in superior infrastructure. I, therefore, expect that cooperatives will be more likely to enter communities where investor-owned providers offer poor quality. The baseline hypothesis is thus:

Hypothesis 1 (H1): The greater the average quality of Internet provision by investor-owned companies in a community, the less likely cooperative providers are to be present in that community.

A negative association between the quality of investor-owned provision and the presence of cooperative providers alone is not especially probative. While consistent with the theoretical arguments, such an association is susceptible to alternate explanations: there may be regulatory or cultural factors constraining investor-owned broadband provision in some communities (Skiti, 2020b), which is why cooperatives do better there, or cooperatives may be simply substituting for low-capability investor-owned firms. To provide stronger evidence for my proposed theory, I want to see the strength of this negative association vary in ways consistent with the theoretical arguments, which I next consider.

First, consistent with Figure 3b, I expect the negative association between the quality of investor-owned provision and cooperative presence to be stronger in low-income communities. Users in these communities will have a limited ability to pay for Internet service, so the revenues of investor-owned firms in such communities are likely to be lower (Greenstein, 2019). At the same time, these communities may see greater externalities from high-speed Internet provision. Because low-income areas will, by definition, have weaker economic opportunities, high-speed Internet access is likely to have a greater marginal effect on life in these communities than in already prosperous communities.

By connecting low-income communities to richer markets elsewhere, high-speed Internet provision may give users access to new educational and entrepreneurial opportunities. These users, in turn, will boost economic opportunity in the region through their increased prosperity and job creation, benefitting even those not directly taking advantage of high-speed access. Overall, bounded externalities are likely to comprise a larger share of the total benefits of high-speed Internet access in low-income communities, so the comparative advantage of cooperative provision should be greater. Thus:

Hypothesis 2 (H2): The negative association between the quality of investor-owned Internet provision and cooperative presence will be stronger in low-income communities than in high-income communities.

A second factor likely to moderate the negative association between the quality of investor-owned provision and cooperative presence, consistent with Figure 3c, is population density (Downes & Greenstein, 2002). Because the cost of installing broadband infrastructure increases with the physical distance covered, communities where users are more geographically dispersed are likely to have higher costs per user, other things being equal. Therefore, the cost per user of high-speed Internet provision in rural communities (with lower population densities than urban communities) is likely higher.

Given the higher costs, investor-owned providers may find it uneconomical to invest in high-quality provision in rural areas based solely on projected revenues (Greenstein, 2019; Greenstein & Prince, 2006). On the other hand, cooperatives may be willing to invest in broadband infrastructure in rural communities, despite facing similar high costs, because they can internalize the benefits to the community from better Internet connectivity. Therefore:

Hypothesis 3 (H3): The negative association between the quality of investor-owned Internet provision and cooperative presence will be stronger in rural communities than in urban communities.

Finally, consistent with Figure 3d, I also expect the strength of the predicted association to vary with the level of social cohesion within the community. The more tightly knit the community from which the cooperative members are drawn, and the more homogenous their preferences, the more effective the functioning of the cooperative (Hansmann, 1996; Hart & Moore, 1996, 1998). Greater social cohesion means that the interests of the cooperative's members are naturally aligned, making it easier to ensure cooperation and limit free-riding (Hart & Moore, 1998; Ostrom, 1990). Stronger social ties may enhance trust and mutual reliance between members, further enabling cooperation (Dorobantu et al., 2017; Granovetter, 1985; Jones et al., 1997; Sugden, 1984). Conversely, where the community is divided into distinct social groups, cooperation between participants may prove more difficult (Yenkey, 2015) and may lead to the exclusion of one group by others, undermining the effectiveness of the cooperative (Yue et el., 2013).

I expect the effectiveness of cooperative provision to be lower in communities with high ethnic diversity and high rates of (inward) immigration. Prior literature has shown that racial and ethnic fragmentation has a negative effect on social participation within a community (Alesina & La Ferrara, 2000), reducing investments in essential public goods (Alesina et al., 1999) and leaving communities vulnerable to outside exploitation (Alesina et al., 2019). In our specific context, I expect that greater ethnic fragmentation within a community will make it more challenging for users within the community to organize as a cooperative, raising the cost of cooperative provision relative to investor-owned provision, as in Figure 3d. More ethnically fragmented communities may also see lower externalities from broadband provision because the indirect benefits from high-speed Internet access may not be shared equally and cooperative members may only care about the gains to members of their own social group rather than the entire community. Similar problems will apply in the case of communities with a high proportion of immigrants. Immigrants may be seen as outsiders to the community, and their presence may therefore limit social cohesion. For all these reasons, I predict:

Hypothesis 4 (H4): The negative association between the quality of investor-owned Internet provision and cooperative presence will be stronger in (a) less ethnically fragmented communities than in more ethnically fragmented communities and (b) in communities with low immigration rates than those with high immigration rates.

These theoretical arguments also imply that cooperatives are more likely to be present in low-income and rural communities with high social cohesion. While this study does not hypothesize a main effect of these variables, choosing to focus instead on their moderating role, this study does empirically examine these relationships.

3.4. Data and Methodology

3.4.1. Data and Variables

This study tests the aforementioned arguments in the context of fixed broadband provision in the United States, using uniquely detailed FCC data from 2014 to 2017 to track Internet provision at the census tract level.[21] All facilities-based Internet providers are required to file FCC Form 477 biannually (every June and December) at the census block level as long as the speed of their Internet service exceeds 0.2 Mbps. The threshold of 0.2 Mbps is very slow, given that checking email

[21] I started the dataset in December 2014, when data filing became mandatory and administered centrally by the FCC, and ended in December 2017, the most recent at the time of the analysis. Prior to our sample period, state entities submitted data to the State Broadband Initiative (SBI) and then to the National Telecommunications & Information Administration (NTIA), resulting in reporting inconsistencies, especially for cooperatives.

or browsing the web requires a minimum of 1–5 Mbps. The FCC thus collects data if there is any Internet connection.

The FCC data include the name of the ISPs, the technology used, and the listed speed of provision.[22] I extracted the December data across four years and aggregated to the census tract level. I analyze at the census tract level, even though the FCC data are available at the census block level. Census tract is the most granular level of geographic resolution with available American Community Survey data provided by the U.S. Census where many predictors and control variables are collected. Moreover, the proposed theory is about communities rather than blocks, and I believe that a census tract—roughly the size of a neighborhood—is a better fit for the theory than a single block.

To collect identity information on the ISPs and distinguish investor-owned providers from cooperative providers and municipal governments, I manually search for these ISPs and triangulate across several databases, including the University of Wisconsin's Cooperative Census, the Institute for Local Self-Reliance's list of Cooperatives Build Community Networks, and the White House's list of U.S. municipalities with broadband networks.[23] In addition, I visit each ISP's website to confirm that it self-identifies as a cooperative and each municipal government's website to confirm municipal Internet service provision. I identify 2,280 unique investor-owned firms, 317 cooperatives, and 225 municipal governments as ISPs that operated during this period. In addition to the FCC data, I also draw on the U.S. Census for the socioeconomic data of the communities. Matching the FCC data to the

[22] While the FCC data offer the most comprehensive measurement of Internet provision in the United States available over time, one limitation is that the reported speeds are listed speeds rather than actual speeds. The actual speed may be influenced by idiosyncratic factors, such as the end users' hardware and software issues, server-side issues, and the number of users in a house.
[23] Accessed at https://files.eric.ed.gov/fulltext/ED584128.pdf

census database gives a final sample of 285,320 census tract-year observations across 71,558 unique census tracts.

Dependent variable. I measure *Coop* as a dummy variable indicating whether a cooperative ISP is present in a given census tract. In robustness analyses, I also differentiate cooperatives by technology type. Specifically, I distinguish between Internet provision using technologies that provide relatively high speeds, which include fixed wireless and fiber, and Internet provision using all other technologies, most of which have significantly lower speeds, especially on uploads.

High-tech coop measure whether a cooperative is present in the given census tract using high-speed technologies, where high-speed technologies are defined as either fixed wireless or fiber.[24] While main measures include all types of cooperative providers, in robustness checks, I distinguish between pure-play Internet cooperatives and various forms of legacy cooperatives (i.e., cooperatives offering other services that also provide Internet) to account for the fact that the latter may face lower costs in the regions they already serve and may also be subject to different regulations when providing Internet services (e.g., easement laws). Results from these robustness checks (see Appendix 3) are consistent with the main findings.

Independent variable. For H1, the main measure of the quality of investor-owned provision is *investor-owned Internet mean speed,* measured as the average Internet upload speed provided by investor-owned ISPs in a given census tract.[25] As the mean and maximum Internet upload speed are 100.4 Mbps and 1000 Mbps (i.e., 1 gigabit), I scale the speed measure by 100. While provision speed is a natural and

[24] A full set of results with a binary measure of high-tech coop presence and a continuous version of our dependent variable based on the speed of cooperative provision are shown in Appendix 2.
[25] For 424 census-tract-year observations (0.14% of the sample) where investor-owned firms do not provide Internet service, I coded this variable as 0. I focused on upload speeds in results reported here, but analyses using download speeds instead are reported in Appendix 4 and show consistent results.

salient measure of Internet service quality, one concern is that speeds listed by the provider may be susceptible to manipulation. Therefore, I use an alternative technology-based measure of quality, *% covered by high tech investor-owned Internet* (i.e., the percentage of a given census tract covered by high-tech [fiber or fixed wireless] investor-owned ISPs).

Moderating variables. I use several additional variables to test the moderating hypotheses, all taken from the census. For H2, which focuses on the differential effects for high- and low-income communities, I measure *log*(*Median HH income)* for a census tract. For H3, which examines the differential effects for urban and rural communities, I count as *Rural* any census tract that includes an area designated as rural by the U.S. Census. This measure is not time-varying within my sample period.

For H4a on the level of social cohesion within the community, I construct a measure for *Ethnic diversity* as an ethnic fractionalization index, following prior literature (Alesina & La Ferrara, 2000; Alesina et al., 1999; Alesina et al., 2019). Specifically, $Ethnic\ diversity = 1 - \sum_i (Race_i)^2$, *where i = {White, Black, Hispanic, Asian, Native Americans, and Other}*. For H4b, I measure *Immigration* as the percentage of the population in a census tract that has immigrated from outside the United States. Data on population ethnicity and migration rates is taken from the census.

Control variables. Most of my analyses include census tract fixed effects and year fixed effects. I include several controls at the census tract level for time-varying characteristics that may determine the quality of investor-owned provision and cooperative presence, including *log(Population)*, *Unemployment rate, % population above 65*, and *% population with bachelor degree or higher*. I also control for Indian reservations by including *% Native Americans.* I include a binary variable *Muni gov. coverage* indicating whether the municipal government provides Internet service in a given census tract. I include a variable *Areas with investor-owned business services* to account for the level of business activities in the area, measured as the number of census blocks in a census tract covered by investor-owned Internet service for business (divided by 100 for ease of interpretation). Finally, I include a measure for the *Number of investor-owned providers* to account for the possibility that cooperatives may be more likely to enter and operate in areas where investor-owned providers face limited competition (Hart & Moore, 1996, 1998), with users coming together to exert countervailing pressure against monopoly providers (Asmussen et al., 2020).

Table 3 provides summary statistics, and Table 4 provides correlation. While there are a few high correlations, mostly between controls, the mean VIF value is 1.40, so I see no cause for concern regarding multicollinearity.

Table 3. Summary Statistics (N = 285,320)

Variable	Mean	Std. Dev.	Min	Max
Coop	0.0727	0.2597	0	1
Investor-owned internet mean speed	1.0047	1.2737	0	10
log(Median HH income)	10.9409	0.4770	8.0388	12.4292
Rural	0.3770	0.4846	0	1
Ethnic diversity	0.3872	0.2038	0	0.8265
Immigration	0.0060	0.0119	0	0.3750
log(Population)	8.2795	0.4894	2.8332	11.0903
Unemployment rate	0.0513	0.0313	0	0.7410
% population above 65	0.1360	0.0838	0	0.9330
% population with bachelor degree or higher	0.2879	0.1862	0	1
% Native Americans	0.0084	0.0440	0	1
Muni. gov.	0.0326	0.1775	0	1
The number of investor-owned providers	5.9604	2.7706	0	32
Areas with investor-owned business services	1.1262	1.2782	0	22.84
IV: CAF funded areas x after 2015	0.0129	0.0485	0	0.6944
% covered by high tech investor-owned internet	0.5794	0.4253	0	1
High tech coop	0.0631	0.2432	0	1
Persistent Poverty Counties (PPC)	0.0718	0.2581	0	1
Coop internet mean speed	1.4753	3.0811	0	10

Table 4. Correlations

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Coop	1																		
2	Investor-owned internet mean speed	-0.0717	1																	
3	log(Median HH income)	-0.0593	0.1619	1																
4	Rural	0.2738	-0.1406	0.0251	1															
5	Ethnic diversity	-0.1655	0.0707	-0.0449	-0.38	1														
6	Immigration	-0.0658	0.0687	0.0115	-0.1892	0.2513	1													
7	log(Population)	-0.0371	-0.0134	0.2015	0.0737	0.1236	0.0272	1												
8	Unemployment rate	-0.1084	-0.0565	-0.495	-0.1941	0.1637	-0.0131	-0.0944	1											
9	% population above 65	0.0585	-0.033	0.0209	0.1472	-0.2761	-0.106	-0.1601	-0.1902	1										
10	% population with bachelor degree or higher	-0.1265	0.1464	0.7078	-0.1967	0.0687	0.2351	0.0827	-0.3829	0.0547	1									
11	% Native Americans	0.0631	-0.0445	-0.0732	0.0913	0.0577	-0.0202	-0.0391	0.0724	-0.0329	-0.0838	1								
12	Muni. gov.	0.0356	-0.0352	-0.0436	0.0765	-0.0217	-0.0146	0.0337	-0.0161	0.002	-0.0271	0.0061	1							
13	The number of investor-owned providers	-0.0887	0.1386	0.1083	-0.1621	0.1695	0.1407	0.1867	-0.0653	-0.085	0.2194	-0.0732	-0.0107	1						
14	Areas with investor-owned business services	0.2624	-0.0129	-0.0337	0.4634	-0.2474	-0.1255	0.1328	-0.1367	0.1009	-0.1721	0.1218	0.0454	0.0726	1					
15	IV: CAF funded areas x after 2015	0.0349	-0.068	-0.0403	0.3099	-0.1535	-0.0756	-0.0232	-0.057	0.0423	-0.1371	0.0335	0.045	-0.0903	0.1585	1				
16	% covered by high tech investor-owned internet	-0.0777	0.4552	0.1466	-0.2281	0.1229	0.0555	0.0335	-0.0519	-0.0811	0.1288	-0.0326	-0.0716	0.3246	0.0717	-0.0957	1			
17	High tech coop	0.926	-0.062	-0.0532	0.2498	-0.1563	-0.0586	-0.0343	-0.108	0.0549	-0.115	0.0528	0.0308	-0.0811	0.2434	0.0289	-0.0709	1		
18	Persistent Poverty Counties (PPC)	0.0586	-0.0012	-0.1935	0.0395	0.0021	0.0028	-0.0583	0.0974	-0.0429	-0.1009	0.1062	0.0135	-0.1145	-0.0091	0.0862	-0.0352	0.06	1	
19	Coop internet mean speed	0.4676	-0.0415	-0.0307	0.1417	-0.0901	-0.0343	0.0019	-0.0498	0.0404	-0.0601	0.0213	0.0294	-0.0445	0.0984	0.0656	-0.0549	0.4981	0.0265	1

3.4.2. Methodology

The baseline specification examines the relationship between the quality of investor-owned provision in a census tract and cooperative presence in that census tract both in the cross-section (between census tracts) and longitudinally (within census tracts). The latter specification estimates the relationship between changes in the quality of investor-owned provision and cooperative entry (or exit[26]) while holding time-invariant characteristics of the community constant. I also included year fixed effects in all regressions to account for changes over time and used robust standard errors clustered at the census tract level. I used a linear probability model in the main models reported below, though results are robust to a variety of other specifications, including logit and tobit models (as shown in Appendix 5).

This baseline specification may provide preliminary evidence of the relationship between the service quality of investor-owned providers and cooperative entry. However, it may be that the choice of cooperative entry is driven by unobserved and time-varying factors, which impact the service quality of investor-owned provision (i.e., there is a potential omitted variable problem). To address this concern, I use an instrumental variable (IV) analysis, exploiting a government program, Connect America Fund (CAF) Phase II, that incentivizes ISPs to invest in underserved areas. Specifically, in April 2015, CAF Phase II offered subsidies to price cap carriers to deploy and maintain basic voice and Internet services in underserved high-cost areas. Under the program, 10 ISPs—all investor-owned providers[27]—received over $1.675 billion in subsidies.

[26] In robustness checks, I focused only on cooperative entry by dropping all census tracts that already have a cooperative provider at the start of our sample period. The results of this analysis, shown in Appendix 5, are consistent with the main findings.
[27] Over 96% of these subsidies went to five large investor-owned players: Century Link, AT&T, Frontier Communications, Windstream Communications, and Verizon.

I measure *% CAF funded area* as the percentage of a given census tract that received subsidies from the CAF fund. I also construct a dummy variable *post year 2015*, coded as 1 for years after 2015 (inclusive) and 0 otherwise, and use *% CAF funded area x post year 2015* as an IV for mean Internet speed provided by investor-owned ISPs. The logic for this IV strategy is as follows.

First, the CAF creates an exogenous source of variation in investor-owned Internet quality across the United States, starting in 2015 (relevance condition). Given budget and cost considerations, the quality of provision required from ISPs under CAF Phase II is low. To qualify for CAF subsidies, investor-owned providers are required to offer 10/1 speeds (a download speed of over 10 Mbps and an upload speed of over 1 Mbps).[28] This speed requirement is much lower than the FCC's controversial broadband benchmark of 25 Mbps download /3 Mbps upload. It is also far below the sample average of investor-owned ISP provision at 100.4 Mbps upload.

As a result, while large investor-owned providers have expanded Internet service to underserved areas, the service has often only satisfied the minimum requirement and has not met the current broadband benchmark. For example, in rural Minnesota, implementing the CAF, only 15% of locations have access to 25 Mbps download /3 Mbps upload services, while most others have access to 10 Mbps download / 1 Mbps upload (Blandin Foundation, 2018). Therefore, investor-owned providers' expansion into underserved areas post-2015 may be associated with a drop in the average quality of Internet access provided by investor-owned providers. In particular, the CAF would cause the average speed of investor-owned provision in the community to drop due to the entry of low-speed providers taking advantage of government subsidies. Such entry may also cause investor-owned providers to

[28] https://www.fcc.gov/consumers/guides/connect-america-fund-phase-ii-faqs

deprioritize higher-quality provision in such areas.

Second, given that all 10 subsidy recipients were investor-owned firms, *% CAF funded area x post year 2015* does not directly alter the likelihood of a cooperative's presence in the census tract (exclusion restriction). One potential concern to the exclusion restriction could be that cooperatives were involved in determining the offers made under CAF Phase II. It seems unlikely that cooperatives were involved in the decision-making process, as only investor-owned providers received such offers. It also seems unlikely that cooperatives would have steered subsidies to their potential competitors in areas they planned to enter.

3.5. Results

3.5.1. Main Findings

Table 5 reports the results for H1. I begin by looking at cooperative provision in the cross-section, with models M1 and M2 showing results from between-effects regression. M1 is the baseline regression with a full set of controls, and M2 adds the main predictor *investor-owned Internet mean speed.*

Consistent with my theory, M1 and M2 show a negative and significant association between the quality of *investor-owned* provision and cooperative presence (β = -0.0104, p < 0.001). In terms of economic magnitude, M2 implies that one standard deviation difference in investor-owned upload speeds between census tracts is associated with a 1.32 percentage point difference in the probability of cooperative presence between them, which is about 18% of the sample mean. M1 and M2 also show that cooperatives are more likely to be present in rural census tracts with low average incomes and low ethnic fragmentation. While I did not explicitly hypothesize these relationships, they are consistent with my theoretical arguments.

M3 and M4 in Table 5 show my main results, including census tract fixed effects. As with M2, I find a negative and significant coefficient for *investor-owned Internet mean speed* ($p < 0.001$) in M4. The results in M4 thus strongly confirm a negative association between *investor-owned Internet mean speed* and *Coop*, with cooperatives more likely to enter census tracts where the speed of investor-owned provision is declining, supporting H1. In terms of economic significance, based on the point estimate of M4, a one standard deviation decrease in *investor-owned Internet mean speed* is associated with a 0.29 percentage point increase in *Coop* (a 51% increase over the average annual increase in *Coop* in a single year of 0.57 percentage points).

Models M5 and M6 report the first and second stages of the IV regressions. Model M5 shows the results of the first stage predicting *investor-owned Internet mean speed*. It shows a strong and significant relationship between % *CAF funded areas x post year 2015* and *investor-owned Internet mean speed* ($\beta = -0.9982$, $p < 0.001$), confirming the relevance of *CAF funded areas x after 2015* as an instrument. Model M6 reports the second stage results of our IV specification and shows a negative and significant coefficient for our instrumented measure ($\beta = -0.088$, $p < 0.001$). Overall, the results in Table 5 lend strong support to H1, showing that the presence of cooperatives is negatively related to the quality of investor-owned provision.

Table 5. Main Results

	DV: Coop				DV: Investor-owned internet mean speed	DV: Coop
	OLS Between M1	OLS Between M2	OLS Within M3	OLS Within M4	2SLS 1st stage M5	2SLS 2nd stage M6
Investor-owned internet mean speed		-0.0104		-0.0023		-0.0880
		(0.0000)		(0.0000)		(0.0000)
log(Median HH income)	-0.0434	-0.0391	0.0163	0.0175	0.5270	0.0626
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.000)	(0.0000)
Rural	0.0743	0.0714				
	(0.0000)	(0.0000)				
Ethnic diversity	-0.0559	-0.0565	-0.0009	-0.0001	0.3238	0.0285
	(0.0000)	(0.0000)	(0.8565)	(0.9787)	(0.000)	(0.0008)
Immigration	0.2377	0.2730	-0.0012	-0.0020	-0.3615	-0.0321
	(0.0068)	(0.0019)	(0.9576)	(0.9296)	(0.398)	(0.4613)
log(Population)	-0.0275	-0.0295	-0.0099	-0.0103	-0.1651	-0.0232
	(0.0000)	(0.0000)	(0.0058)	(0.0043)	(0.001)	(0.0001)
Unemployment rate	-1.1459	-1.1295	0.0581	0.0635	2.3596	0.2645
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.000)	(0.0000)
% population above 65	-0.1015	-0.1162	0.0201	0.0239	1.6787	0.1681
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.000)	(0.0000)
% population with bachelor degree or higher	-0.0587	-0.0581	-0.0356	-0.0352	0.1402	-0.0217
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.158)	(0.0504)
% Native Americans	0.1418	0.1337	0.0757	0.0763	0.2627	0.0964
	(0.0000)	(0.0000)	(0.0654)	(0.0635)	(0.474)	(0.0637)
Muni. gov.	0.0158	0.0143	0.0074	0.0072	-0.0882	-0.0009
	(0.0023)	(0.0059)	(0.0792)	(0.0888)	(0.016)	(0.8766)
The number of investor-owned providers	-0.0058	-0.0053	0.0016	0.0018	0.0840	0.0089
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.000)	(0.0000)
Areas with investor-owned business services	0.0363	0.0367	0.0013	0.0025	0.4962	0.0442
`	(0.0000)	(0.0000)	(0.2400)	(0.0370)	(0.000)	(0.0000)
IV: % CAF funded area * post year 2015					-0.9982	
					(0.000)	
Constant	0.8936	0.8677	-0.0224	-0.0328		
	(0.0000)	(0.0000)	(0.5273)	(0.3562)		
Observations	285,320	285,320	285,320	285,320	285,197	285,197
Number of censustractid	71,558	71,558	71,558	71,558	71,435	71,435
R-squared(between)	0.130	0.131	0.0099	0.0203		
R-squared(overall)	0.110	0.110	0.0084	0.0163		
Kleibergen-Paap rk Wald F-statistic					313.64	
Cragg-Donald Wald F statistic					199.98	
Endogeneity test of endogenous regressors[P-val]					64.474[0.0000]	

Note. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses. Stock-Yogo weak ID test critical value at 10% maximal IV size is 16.38.

3.5.2. Moderating Roles of Low-Income, Rurality, and Social Cohesion

Next, I consider the factors moderating this main result. I test the moderating hypotheses using a split sample approach because the moderators are either entirely time invariant (e.g., rural vs. urban) or vary little with time (Shaver, 2019). Table 6 shows the results of running within-effects regressions in split samples corresponding to my hypotheses.[29] Specifically, H2 predicted that the negative association between the quality of investor-owned provision and cooperative presence would be stronger in low-income communities. M7a and M7b in Table 6 find a negative and significant coefficient for *investor-owned Internet mean speed* in both high-income ($\beta = -0.0021$, $p < 0.001$) and low-income communities ($\beta = -0.0018$, $p < 0.001$). The p-value of a t-test comparing the coefficients is 0.39, suggesting the two coefficients are not statistically different from each other. Thus, H2 is not supported.

H3 predicted the negative association between the quality of investor-owned provision and cooperative presence will be stronger in rural communities than in urban communities. While M8a and M8b both show a negative and significant coefficient for *investor-owned Internet mean speed,* the size of the coefficient is greater in rural communities ($\beta = -0.0029$, $p < 0.001$) than in urban communities ($\beta = -0.0009$, $p < 0.001$), with the p-value of a t-test comparing the coefficients being less than 0.001, offering strong support for H3. The negative relation between the declining quality of investor-owned provision and cooperative entry in the main analysis is substantially stronger in rural communities.

H4a predicted that the negative association between the quality of investor-owned broadband provision and cooperative presence will be stronger in less ethnically fragmented communities than in more ethnically fragmented communities. H4b predicted a similar relationship for communities with lower immigration rates than those with higher immigration rates. M9a and M9b show a negative and significant coefficient for *investor-owned Internet mean speed* in both high ethnic diversity ($\beta = 0.0014$, $p < 0.001$) and low ethnic diversity communities ($\beta = -0.0031$,

[29] Samples are split based on the rural/urban designation previously defined and the median values of *log(Median HH income)*, *Ethnic diversity*, and *Immigration* in the sample.

Table 6. Moderation Results

	DV: coop							
	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M7a	M7b	M8a	M8b	M9a	M9b	M10a	M10b
Investor-owned internet mean speed	-0.0021	-0.0018	-0.0009	-0.0029	-0.0014	-0.0031	-0.0016	-0.0028
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
log(Median HH income)			0.0059	0.0466	0.0109	0.0223	0.0126	0.0233
			(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ethnic diversity	0.0008	-0.0001	0.0010	0.0067			-0.0000	-0.0003
	(0.9048)	(0.9844)	(0.7772)	(0.5920)			(0.9964)	(0.9728)
Immigration	-0.0125	-0.0038	0.0234	-0.0500	-0.0234	0.0784		
	(0.6628)	(0.9145)	(0.2450)	(0.5805)	(0.3163)	(0.1762)		
log(Population)	-0.0038	-0.0079	-0.0079	-0.0080	-0.0107	-0.0012	-0.0040	-0.0115
	(0.5122)	(0.0858)	(0.0021)	(0.3605)	(0.0049)	(0.8615)	(0.3677)	(0.0416)
Unemployment rate	0.1003	0.0544	0.0158	0.0827	0.0460	0.0630	0.0442	0.0820
	(0.0000)	(0.0009)	(0.0907)	(0.0319)	(0.0018)	(0.0059)	(0.0071)	(0.0000)
% population above 65	0.0147	0.0176	0.0078	0.0505	-0.0011	0.0446	0.0129	0.0357
	(0.0000)	(0.0017)	(0.0001)	(0.0000)	(0.8349)	(0.0000)	(0.0013)	(0.0000)
% population with bachelor degree or higher	-0.0118	-0.0295	-0.0130	-0.0695	-0.0243	-0.0474	-0.0294	-0.0371
	(0.1731)	(0.0078)	(0.0119)	(0.0005)	(0.0008)	(0.0003)	(0.0004)	(0.0021)
% Native Americans	0.0209	0.1070	0.0296	0.0958			0.0709	0.0760
	(0.7498)	(0.0429)	(0.3261)	(0.2569)			(0.1985)	(0.2079)
Muni. gov.	0.0079	0.0062	0.0026	0.0076	0.0007	0.0120	0.0050	0.0091
	(0.0841)	(0.3596)	(0.2761)	(0.2927)	(0.8136)	(0.0837)	(0.4018)	(0.1324)
The number of investor-owned providers	0.0019	0.0015	0.0006	0.0012	0.0009	0.0026	0.0015	0.0018
	(0.0000)	(0.0000)	(0.0000)	(0.0080)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Areas with investor-owned business services	-0.0016	0.0043	0.0007	0.0001	0.0020	0.0023	0.0002	0.0030
	(0.4653)	(0.0009)	(0.7320)	(0.9549)	(0.0668)	(0.1749)	(0.9336)	(0.0391)
Test of differences across split samples[P-val]:	0.74[0.3904]		38.56[0.0000]		36.84[0.0000]		17.28[0.0000]	
Constant	0.0833	0.1545	0.0195	-0.2671	0.0156	-0.1299	-0.0522	-0.0652
	(0.0874)	(0.0000)	(0.4629)	(0.0038)	(0.6666)	(0.0497)	(0.2553)	(0.2307)
Observations	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0015	0.0167	0.0001	0.0003	0.0106	0.0081	0.0029	0.0136

Note. Ordinary least squares (OLS) fixed effects regression. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses.

$p < 0.001$), with the latter more negative than the former. This finding is consistent with H4a, with a significant difference between the two coefficients ($p < 0.001$).

M10a and M10b show a similar pattern for high immigration ($\beta = -0.0016$, $p < 0.001$) and low immigration ($\beta = -0.0028$, $p < 0.001$) communities, with the relationship of interest being significantly stronger in low immigration than in high immigration communities ($p < 0.001$). This finding is consistent with H4b. These results support the prediction that cooperatives will be more effective in communities with greater social cohesion.[30]

3.5.3. Supplementary Analyses and Robustness

Technology of investor-owned provision. I run several supplementary analyses. First, I replace the main independent variable—*investor-owned Internet mean speed*—with a measure of the technology of investor-owned provision, *% covered by high tech investor-owned Internet*, as an alternative measure of investor-owned quality in Table 7.

Table 7 provides results similar to those in Tables 5 and 6, with the new independent variable showing a negative and significant association with cooperative presence in both within-effects ordinary least squares (OLS; M11) and IV (M13) regressions (consistent with H1). This association is stronger in rural communities than in urban communities (M16a-b, in line with H3) and in communities with low immigration compared to those with high immigration (M18a-b, in line with H4b). In addition, Table 7 shows results directionally in line with H4a, with the coefficient for *% covered by high-tech investor-owned Internet* being more negative in communities with low-ethnic fragmentation than those with high-ethnic

[30] In unreported supplementary analyses, I also ran a four-way split distinguishing between urban and rural communities with high and low ethnic communities and (separately) high and low immigration levels. Interestingly, I find that the negative association of interest is strongest in rural communities with low ethnic diversity.

Table 7. Supplementary Analyses on Technology Choice

	DV: Coop	DV: High tech coop	DV: Coop	DV: High tech coop	DV: Coop							
	Full sample analyses				Subsample analyses using OLS fixed effects							
	OLS Within	OLS Within	2SLS 2nd stage	2SLS 2nd stage	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M11	M12	M13	M14	M15a	M15b	M16a	M16b	M17a	M17b	M18a	M18b
% covered by high-tech investor-owned internet	-0.0056	-0.0073	-0.8051	-0.8106	-0.0047	-0.0055	-0.0013	-0.0105	-0.0047	-0.0069	-0.0038	-0.0070
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0280)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
Test of differences across split samples[P-val]:					0.24[0.6275]		20.47[0.0000]		2.05[0.1522]		4.10[0.0429]	
Constant	-0.0208	-0.0188			0.0734	0.1558	0.0247	-0.2625	0.0229	-0.1150	-0.0461	-0.0486
	(0.5570)	(0.6792)			(0.1320)	(0.0000)	(0.3521)	(0.0044)	(0.5278)	(0.0816)	(0.3162)	(0.3698)
Observations	285,320	285,320	285,197	285,197	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	71,558	71,435	71,435	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0183	0.0173			0.0032	0.0185	0.000001	0.0004	0.0161	0.0073	0.0039	0.0151
Cragg-Donald Wald F statistic			43.44									
Kleibergen-Paap Wald rk F statistic			49.73									
Endogeneity test of endogenous regressors[P-val]			66.989[0.0000]	64.549[0.0000]								

Note. All control variables are included. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses. Stock-Yogo weak ID test: critical value at 10% maximal IV size is 16.38.

fragmentation (M17a-b), though the difference between the two coefficients is not significant at conventional levels ($p = 0.1522$).

Furthermore, models M12 and M14 in Table 7 use an alternative dependent variable *High-tech coop*, which takes the value 1 if a cooperative provides broadband in the community using a high-speed technology (fiber or fixed wireless). M12 shows the results for a fixed effects OLS, and M14 shows the second stage of our IV 2SLS specification. As with the main dependent variable, there is a negative and significant association of this measure with high-tech investor-owned presence, implying that cooperatives not only are more likely to enter markets where investor-owned provision is low quality (primarily DSL or cable) but also are likely to do so with higher-quality technologies. Appendix 2 reports additional results using this alternative measure and a continuous measure of cooperative quality. These results imply that cooperatives tend to upgrade the provision quality in the communities they enter, providing high-speed service using high-quality technologies in areas where investor-owned provision is basic at best.

Income. To further explore the role of income as a moderating variable (H2), I run supplementary analyses in Table 8. Specifically, I divide the sample by income quartiles and run a split sample analysis using the same specification as in Table 6, M7. In models M19a-d and models 21a-d, I find that the negative association between both measures of investor-owned Internet quality and cooperative entry is stronger for communities with median income levels at 25%–75% of the sample and weaker for communities in the top and bottom income quartiles. While this is not what I hypothesized, the relationship is weaker in the highest income communities than in those with medium income levels, which is consistent with the theory. Possibly in the poorest communities, even the internalization of the community benefits of cooperative broadband may be insufficient to justify the investment in high-speed technologies, so such communities may have to rely on poor quality (investor-owned) provision.

Next, I consider an alternative measure of community income: the community's status as a persistent poverty county (PPC).[31] As Table 4 shows, the correlation between PPC status and median income levels is relatively modest, suggesting that in many communities moderate-to-high median income levels may mask substantial inequalities in income distribution. Persistent poverty county status can thus be considered a marker of structural inequality in a community, with such communities (or groups within them) potentially benefitting substantially from the bounded externalities of broadband provision.

I run a split sample analysis (M20a-b and M22a-b) based on PPC status using *investor-owned Internet mean speed* and *% covered by high-tech investor-owned Internet* as the main predictors, respectively. I find that the relationship between the quality of investor-owned provision and cooperative presence is more negative for PPCs than non-PPCs, with the difference strongly significant in M20a-b ($p < 0.001$) and not in M22a-b ($p = 0.45$).

Taken together, the results in Table 8 offer partial support for H2. While cooperatives do not necessarily compensate for low-quality investor-owned provision in communities with the lowest average household income, they are more likely to do so in communities with moderate rather than high average incomes and in communities with persistently high poverty rates.

[31] The American Recovery and Reinvestment Act of 2009 defines PPCs as counties with 20 percent or more of their population living in poverty over the past 30 years.

Table 8. Supplementary Analyses on Income

	DV: Coop											
	Median HH income				Non-PPC	PPC	Median HH income				Non-PPC	PPC
	(1): >75%	(2): 50-75%	(3): 25-50%	(4) : <25%			(1): >75%	(2): 50-75%	(3): 25-50%	(4) : <25%		
	M19a	M19b	M19c	M19d	M20a	M20b	M21a	M21b	M21c	M21d	M22a	M22b
Investor-owned internet mean speed	-0.0008	-0.0026	-0.0028	-0.0008	-0.0020	-0.0041						
	(0.0210)	(0.0000)	(0.0000)	(0.0079)	(0.0000)	(0.0000)						
% covered by high-tech investor-owned internet							-0.0001	-0.0074	-0.0099	-0.0015	-0.0053	-0.0082
							(0.9583)	(0.0000)	(0.0000)	(0.2562)	(0.0000)	(0.0254)
Test of differences across split samples[P-val]:												
(1)&(2)		17.27[0.0000]			13.21[0.0003]			8.12[0.0044]			0.57[0.4500]	
(2)&(3)		0.19[0.6649]						1.13[0.2875]				
(3)&(4)		22.36[0.0000]						14.27[0.0002]				
(1)&(3)		18.55[0.0000]						12.32[0.0004]				
(1)&(4)		0.00[0.9548]						0.31[0.5802]				
(2)&(4)		21.37[0.0000]						9.29[0.0023]				
Constant	0.1734	0.1385	0.1397	-0.0533	0.1372	0.1637	0.1747	0.1354	0.1336	-0.0631	0.1362	0.1884
	(0.0000)	(0.0532)	(0.0704)	(0.3282)	(0.0000)	(0.0359)	(0.0000)	(0.0590)	(0.0838)	(0.2486)	(0.0000)	(0.0152)
Observations	71,332	71,332	71,332	71,324	264,846	20,474	71,332	71,332	71,332	71,324	264,846	20,474
Number of censustractid	17,864	17,846	17,859	17,989	66,413	5,145	17,864	17,846	17,859	17,989	66,413	5,145
R-squared(overall)	0.00006	0.0477	0.00005	0.0402	0.0149	0.0504	0.00005	0.0527	0.00007	0.0427	0.0161	0.0451

Note. OLS fixed effects regressions. All control variables are included. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses. PPC refers to persistent poverty counties and are defined as any county that has had 20 percent or more of its population living in poverty over the past 30 years.

Table 9. Supplementary Analyses on Municipal Government Provision

DV: Muni. gov.

Panel A

	Full sample OLS within	Subsample analyses using OLS fixed effects							
		High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M23	M24a	M24b	M25a	M25b	M26a	M26b	M27a	M27b
Investor-owned internet mean speed	-0.0003	-0.0007	0.0004	-0.0007	0.0006	-0.0007	-0.000002	-0.0006	-0.0001
	(0.0123)	(0.0000)	(0.1302)	(0.0000)	(0.0317)	(0.0000)	(0.9910)	(0.0003)	(0.7754)
Test of differences across split samples[P-val]:		13.83[0.0002]		18.51[0.0000]		7.02[0.0081]		4.61[0.0318]	
Constant	0.0049	-0.0607	0.0248	-0.0246	0.0870	-0.0168	0.0305	-0.0129	0.0226
	(0.8495)	(0.1092)	(0.3505)	(0.4174)	(0.0688)	(0.6552)	(0.3529)	(0.7375)	(0.5019)
Observations	285,320	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0040	0.0023	0.0021	0.000006	0.0033	0.0016	0.0017	0.0031	0.0026

Panel B

	Full sample OLS within	Subsample analyses using OLS fixed effects							
		High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M28	M29a	M29b	M30a	M30b	M31a	M31b	M32a	M32b
% covered by high-tech investor-owned internet	-0.0008	-0.0010	-0.0002	-0.0016	0.0030	-0.0026	0.0011	-0.0024	0.0007
	(0.1923)	(0.1977)	(0.7893)	(0.0045)	(0.0242)	(0.0001)	(0.2487)	(0.0045)	(0.4043)
Test of differences across split samples[P-val]:		0.47[0.4943]		10.17[0.0014]		10.33[0.0013]		6.67[0.0093]	
Constant	0.0066	-0.0650	0.0243	-0.0205	0.0866	-0.0131	0.0304	-0.0099	0.0230
	(0.7970)	(0.0859)	(0.3604)	(0.5001)	(0.0701)	(0.7284)	(0.3565)	(0.7959)	(0.4954)
Observations	285,320	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0044	0.0024	0.0025	0.0001	0.0024	0.0035	0.0014	0.0045	0.0021

Note. All control variables are included. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses.

Municipal providers. I have focused on the comparative advantage of cooperatives relative to investor-owned firms as ISPs; however, municipal providers are another organizational form providing broadband access. To understand the municipal provision of Internet services, I ran analyses on municipal provider entry in Table 9.

I find evidence of a negative association between investor-owned provision quality and municipal provider presence, though only with the speed-based measure of investor-owned quality (Panel A). Interestingly, Table 9 shows strong and consistent evidence for a negative association between investor-owned quality and municipal provision in high-income, urban areas with high ethnic fragmentation and high immigration levels, with no evidence of such an association in low-income, rural, or more socially cohesive areas (i.e., the opposite of the pattern of moderations seen with cooperatives). These results suggest a diverging pattern of infrastructure governance, with cooperatives taking up the slack for investor-owned providers in rural and low-income communities and municipal providers in urban and high-income communities. Perhaps it is because municipal governments are the strongest in those areas or, in some cases, because regulations prohibit them from entering certain markets[32] (Skiti, 2020b).

3.6. Discussion

This study sheds new light on the role of cooperatives in providing infrastructure to marginalized communities. I find that cooperatives are more likely to enter communities underserved by investor-owned providers with lower speed technologies.

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[32] In recent years, approximately 20 states have passed regulations limiting municipal providers from providing broadband services outside their city jurisdictions, often modeled on a draft bill created by the American Legislative Exchange Council. A recent Sixth Circuit Court of Appeals ruling in *Tennessee v. FCC* (2016) upheld Tennessee's and North Carolina's right to limit municipal provision in this way.

This association is stronger in rural communities and communities with moderate income levels and weaker in communities with high ethnic diversity or high immigration rates. These results are robust to using an IV approach to improve identification. Supplementary analyses suggest that when cooperatives enter communities with low-quality investor-owned provision, cooperatives tend to bring more advanced technologies (fixed wireless or fiber) and offer higher speeds, thus raising the quality of Internet access. Supplementary analyses also suggest these patterns are distinct from municipal ISPs, which may also serve communities with weak investor-owned provision but primarily in high-income or urban communities, potentially with lower social cohesion.

These findings contribute to understanding firm strategy at the intersection of public and private interests (Cabral et al., 2019; Mahoney et al., 2009). Recent work in this area has stressed the need for a comparative governance approach to systematically examine the institutional arrangements that most effectively and efficiently deal with these challenges (Kaul & Luo, 2018; Klein et al., 2019; Lazzarini, 2019; Luo & Kaul, 2019). This study complements and extends this past work by examining the benefits and costs of two distinct governance arrangements—investor-owned firms and cooperatives—in infrastructure provision. It makes a theoretical contribution by clearly delineating the nature of infrastructure provision as an economic activity. It links the characteristics of this activity to the governance forms best suited to handling it and develops a general theory for the conditions under which cooperatives or investor-owned firms will be the comparatively efficient organizational form for providing infrastructure (Luo & Kaul, 2019).

This study also empirically contributes by testing the theoretical predictions in the context of broadband provision. It provides a large sample of evidence in support of the theory and offers one of the first empirical studies examining public-private interests through a comparative governance lens, thus complementing a stream of theoretical work in this area (Klein et al., 2019; Lazzarini, 2019; Luo & Kaul, 2019). This study also offers new insights into the role of cooperatives—moving past the factors that make cooperatives successful, such as external community-level influences (Boone & Özcan, 2014; Ingram & Simons, 2000; Simons & Ingram, 2003) or internal tensions (Yue et al., 2013)—to develop a theoretical account of the comparative advantage of cooperatives as an organizational form (Hansmann, 1996; Hart & Moore, 1996, 1998; Luo & Kaul, 2019).

The theory and findings also speak to an ongoing policy debate about infrastructure provision. While the critical role of infrastructure in enabling economic development is well understood, there remains considerable disagreement over how that objective is best accomplished. While some favor large investments by the state, others believe the provision of infrastructure is best entrusted to the private sector.

This study highlights a third option: the use of local cooperatives (Ostrom, 1990). More specifically, it suggests that cooperatives may be especially effective in driving high-quality infrastructure provision in marginalized (often rural) areas, where the gains from infrastructure provision come primarily from the positive externalities generated for the local community and where investor-owned firms may have limited incentive to invest. This is important because the divide between marginalized communities and more prosperous ones is often the focus of concern, especially in the context of digital inequality (Council of Economic Advisers, 2016; DiMaggio et al., 2001; Greenstein, 2019; Seamans, 2018).

As with any study, this work has several limitations. First, while the FCC data this study uses to test these theoretical arguments offer the most comprehensive measurement of Internet provision in the United States available over time, I acknowledge the data are far from perfect. The speeds reported are listed speeds rather than actual speeds, and the FCC counts a census block as "covered" if only one household in the block receives service. The data thus suffer from substantial measurement error, which makes our results potentially noisy, though I see no reason why it would bias in favor of predictions in this study. Second, our empirical analyses focus primarily on cooperative presence (as well as their choice of technology); we do not examine how investor-owned providers react to cooperative presence (Seamans, 2012; Skiti, 2020a) or the evolving nature of competition between them: questions worth exploring in future work. Future work could also look further into the role of regulatory and normative institutions (Skiti, 2020b) in driving heterogeneity of cooperative presence across regions.

To conclude, this paper takes a comparative governance approach to infrastructure provision and asks: When are cooperatives better at providing infrastructure than investor-owned firms? The answer is when the direct revenues from infrastructure provision are relatively low compared to costs, investor-owned firms have little incentive to invest in high-quality provision. In such cases, cooperatives may be more willing to provide high quality infrastructure because, being user owned and controlled, they can internalize the externalities generated for the community by high-quality infrastructure.

This study tests these arguments in the context of broadband provision, showing that cooperatives are more likely to enter communities where the existing investor-owned firms offer low-quality Internet access. This relationship is stronger for rural communities and communities with low-social cohesion. It is robust to account for the endogeneity of low-quality investor-owned provision. This study thus contributes to a growing body of work on strategies at the intersection of public and private interests, highlighting the potential role of cooperatives in effectively providing high-quality infrastructure in otherwise marginalized areas.

CHAPTER 4.

COOPERATIVES AS ENTRANTS AND INCUMBENTS' TECHNOLOGY UPGRADES

4.1. Introduction

Numerous cooperatives generate sizable revenues in multiple economic sectors where investor-owned firms are in and enter new markets where investor-owned firms are dominant. However, little work has closely examined the competitive effects of cooperatives. Prior works have focused on the factors that make cooperatives more or less successful (Boone & Özcan, 2014; Chatterji et al., 2020; Ingram & Simons, 2000; Schneiberg et al., 2008) and the comparative efficiency of cooperatives (Jeong et al., 2020; Luo & Kaul, 2019). This is despite theoretical works arguing that cooperatives play a pro-competitive role, serving as ways for consumers, suppliers, etc. to countervail market power (Asmussen et al., 2020; Galbraith, 1952; Sexton, 1990; Sexton & Sexton, 1987; Stiglitz, 2009). This paper, therefore, empirically examines the competitive effects of cooperatives and how their effects differ from those of investor-owned firms. I ask the following question: Under what conditions does cooperative entry drive stronger competitive reactions from incumbents than investor-owned firm entry?

Two main characteristics of consumer cooperatives in relation to investor-owned firms may make cooperative entry more threatening to incumbents than investor-owned firm entry. First, consumer ownership allows cooperatives to internalize consumer surplus and community externalities so that cooperatives are incentivized to maximize them (Jeong et al., 2020; Luo & Kaul, 2019). Therefore, cooperatives are likely to provide higher-quality service at a more favorable price to consumers than their investor-owned counterparts. At the same time, being consumer-oriented will lead to greater consumer trust and loyalty (National Cooperative Business Association, 2003), helping cooperatives attract and retain consumers from incumbents.

Second, cooperatives are formed to serve consumers, often to countervail existing market power, and are unlikely to have a mutual understanding with incumbents. On the other hand, investor-owned firms may be incentivized to minimize competition and maximize profit. Therefore, I expect that cooperative entrants will force incumbents to show stronger responses than investor-owned firm entrants, especially in markets with a low level of competition and for incumbents with the ability and incentive to respond aggressively to a competitive threat.

I test these arguments using a detailed fixed broadband deployment dataset from the FCC spanning 2014–2018. I measure incumbents' competitive responses as quality improvements or upgrades to high-tech that provide the highest symmetric upload/download speeds.[33] The U.S. broadband industry is an ideal setting to test these arguments for the following reasons.

First, while investor-owned providers are the dominant organizational form in the broadband industry, a growing number of alternative organizational forms, such as cooperatives and municipal governments,[34] have started providing services, increasing competition among heterogeneous organizational forms. Second, because broadband

[33] Several cooperatives told me that incumbents react to entry by lowering their prices and sometimes concurrently improving quality; however, to my knowledge, comprehensive Internet subscription pricing data is unavailable. Therefore, I use quality improvement (upgrade to high-tech) to measure incumbents' competitive responses, which is a more conservative measure than pricing change.

[34] I manually identified 327 cooperatives and 154 municipal governments using FCC data from 2014–2018.

services are geographically bounded, geographic markets are a relatively accurate boundary for defining the availability of service options for consumers and the intensity of competition among providers. Third, because the FCC strictly enforces mandatory filing on almost every ISP in the United States, sampling bias is not a concern. Fourth, Internet services are relatively uniform and vary primarily in terms of quality, allowing the comparison of service qualities and measuring quality improvements.

Using Coarsened Exact Matching (CEM) and a panel event study, I find that investor-owned incumbents are more likely to upgrade to high-tech in response to cooperative entry than in response to investor-owned firm entry. When cooperatives enter, the likelihood of incumbents upgrading to high-tech is 7.3 percent points higher than when investor-owned firms enter. In addition, such effects are stronger in markets with a low level of competition, measured by only one or two high-quality providers, than in markets with more than two high-tech providers. The effects are stronger for the seven biggest providers (AT&T, Frontier, Charter, Comcast, CenturyLink, Verizon, and Windstream) than for smaller and local providers.

Furthermore, the results are consistent even when cooperatives and investor-owned firms only enter with high-tech services. This suggests the effects of cooperative entry on incumbents' responses driven by incumbents trying to match with entrants' technology level and by cooperatives' unique advantages in countervailing market power. An unwillingness to have a mutual understanding with incumbents to minimize competition and a strong consumer orientation inspires greater consumer trust and loyalty, which is a bigger threat than investor-owned entrants.

This paper makes several contributions to the literature. First, this study expands on previous studies on cooperatives in management (Boone & Özcan, 2014, 2016; Chatterji et al., 2020; Ingram & Simons, 2000; Jeong et al., 2020; Schneiberg et al., 2008). This study empirically examines the competitive effects of cooperatives and how their effects differ from those of investor-owned firms. This study contributes to understanding competitive dynamics among heterogenous organizational forms (Casadesus-Masanell & Ghemawat, 2006; Chatterji et al., 2020; Wang & Shaver, 2014, 2016). Second, by investigating incumbents' responses to cooperative entry and investor-owned firm entry, this study adds to the literature examining investor-owned incumbents' reactions to entry by alternative organizational forms (e.g., Seamans, 2012).

Finally, this study has an important implication for public policy. Several scholars have criticized cooperatives for traditionally holding a favored position (e.g., their exemption from the federal corporate income tax; Porter & Scully, 1987; Sexton, 1990). This study empirically demonstrates that cooperative entrants in markets with limited competition drive incumbents to behave more competitively than investor-owned entrants, ultimately benefiting consumers. Thus, the findings from this paper provide corroborating evidence to justify such favorable policies toward cooperatives. In particular, this study illustrates cooperatives' critical role in bridging the digital divide—social and economic inequalities stemming from unequal access to broadband—by driving incumbent ISPs to improve their Internet service quality in markets lacking competition.

4.2. Theoretical Background

4.2.1. *Benefits of Cooperatives*

Drawing on the new institutional economics, Hansmann (1996) explained how assigning ownership to the group of patrons (e.g., investors, consumers, producers) who are most likely to be affected by the transaction can minimize problems arising from market or regulation failures. For example, consumers would be vulnerable to serious exploitation if they relied on market contracting with an investor-owned firm to purchase electricity because local electricity networks are natural monopolies, often leading governments to regulate their rates.

However, such regulation has costs of its own: setting rates too low will reduce the incentive to invest, and giving little slack between actual costs and the allowable rates will reduce the incentive for cost reduction. In such cases, aligning a firm's interests with those of consumers can eliminate the costs of monopoly and rate regulation. Moreover, when the transaction affects local externalities (e.g., when local economic development heavily depends on the reliable supply of electricity), local members with shared interests and familiarity with the local situation can provide a more efficient solution (e.g., a local rural electric cooperative) than an investor-owned utility firm or government regulation (Andersson & Ostrom, 2008; Luo & Kaul, 2019; Ostrom, 1990, 2005).[35] In marginalized communities where investor-owned firms underserve vital infrastructure due to low expected profits, cooperatives can provide high-quality infrastructure because they are

[35] Such comparative efficiencies of electric cooperatives are illustrated by the fact that cooperatives currently own and maintain 42% of electric distribution lines, which serve 42 million people and 56% of the landmass in the United States (National Rural Electric Cooperative Association, 2021).

owned by local members who can internalize community benefits from the infrastructure in a way that investor-owned firms cannot (Jeong et al., 2020).

In addition to the benefits members gain in communities unserved by investor-owned firms, cooperatives may further reduce market failures by forcing incumbents to behave more competitively. It has been suggested that cooperatives may reduce market inefficiencies created by market power by directly competing with a power holder (Peterson & Anderson, 1996; Sexton, 1990; Sexton & Sexton, 1987) or bargaining with a power holder (Asmussen et al., 2020; Galbraith, 1952). This study examines the former case because, in the U.S. Internet service industry, consumer cooperatives directly compete with investor-owned firms rather than form a consumer coalition and bargain with them to counter the market power.[36] Compared to investor-owned firms, consumer cooperatives may drive incumbents to behave more competitively when they enter a market for two main reasons.

First, consumer ownership means that consumer cooperatives internalize consumer surplus and community externalities that eventually benefit consumers and, thus, are incentivized to maximize them (Jeong et al., 2020; Luo & Kaul, 2019). As a result, cooperatives tend to be more consumer-focused and less likely to exploit consumers than investor-owned firms, even when competition is limited (Stiglitz, 2009). Accordingly, cooperatives will prioritize member benefits over profits and offer high-quality products and services at favorable prices to their members. In contrast, investor-owned firms aim to maximize profits, which will produce the “competitive yardstick

[36] Cooperatives in various industries show different ways of countervailing market power. For example, in the agriculture industry, farmers often formed marketing cooperatives to increase their bargaining power and negotiate better prices with downstream firms.

effect” on incumbents (Sexton, 1990; Sexton & Sexton, 1987). As incumbent firms must at least match or exceed the entrant’s offering to avoid losing their market share and profits, they will behave more competitively (e.g., reduce prices, upgrade quality) when facing a cooperative entry than when facing an investor-owned firm entry.

I interviewed cooperative managers who support the argument that cooperatives enter with higher-quality services than incumbents and consumers switch to the high-quality service as soon as possible.

> “For the most part, when we provide services outside of our incumbent area, we know before going in that we can beat the competition hands down. Often this is because we are a fiber provider, and we know that we can always beat them with speed and service even if we might be a bit higher on price.” (L. Carlson, personal communication, March 30, 2021; Chief Sales & Marketing Officer of Norvado, an Internet cooperative)

> “Local customers are frustrated with the lack of service availability and quality of services that are available from incumbents. We are seeing that a lot of customers are switching to our service as soon as their contracts are up, and even paying the early termination fees to leave the other providers and switch to us as soon as our service expands to their area.” (C. Erwin, personal communication, April 2021; Energy Services Director of Plumas-Sierra Telecommunications, an Internet cooperative)

Such consumer demands for high-quality Internet will force incumbents to react to entry by improving quality and lowering prices to secure their customers. One manager from a cooperative describes incumbents' reaction to entry as follows:

> "The first line of attack is usually a financial appeal tied to securing the customer for an extended period. Oftentimes this is in the form of an offer of dramatically reduced first year with the revenue regained in the subsequent locked in two or four additional years. The other method for incumbents is to improve speeds." (A. Bradshaw, personal communication, March 30, 2021; General Manager of Co-Mo Connect, an Internet cooperative)

Similarly, in-depth interviews with CEOs from 21 northeast U.S. cooperatives reported that noncooperative firms try to meet or exceed the price and quality standards set by cooperatives (Peterson & Anderson, 1996).

Furthermore, being consumer-oriented inspires greater trust and loyalty among consumers (Sabatini et al., 2013). A National Cooperative Business Association (2003) survey found that 77% of 2,031 adult American consumers think cooperatives have consumers' best interests in mind, whereas only 47% think the same about investor-owned firms. Similarly, more than 76% believe cooperatives run their businesses in a trustworthy manner and are committed to and involved in their communities. Almost 80% think cooperatives are committed to providing the highest quality services. However, only around 50% of respondents believe the same was true of investor-owned firms.

In Particular, consumer ownership with a democratic system reduces information asymmetry between firms and consumers and allows consumers to feel in control (Bowles & Gintis, 1986; Dahl, 1985; Hansmann, 1996). It is especially so when the quality of goods and services is difficult to assess, as firms have an incentive to deliver lower-quality performance than they promise (Akerlof, 1970), and consumers have an incentive to distrust firms. Additionally, unlike passive consumers of investor-owned firms who can simply stop being patrons if they do not like the products or services, cooperative members become more deeply involved by taking on several responsibilities. These responsibilities include patronizing the cooperative (even when competitors make more attractive offers), staying informed about the cooperative, selecting and evaluating directors, providing necessary capital, and assessing the performance of the cooperative (USDA, 2011). The greater consumer trust and loyalty secured through these responsibilities imply that cooperative entrants have an advantage in taking consumers from incumbents compared to investor-owned entrants, leading to stronger competitive responses from incumbents in response to cooperative entry than investor-owned firm entry.

Second, cooperatives are unlikely to have a mutual understanding with incumbents. Many cooperatives describe themselves as grassroots movements that arose to countervail market power. Having tacit arrangements with powerful market actors who exploit the same people who own the cooperatives is contrary to the reason for forming cooperatives (e.g., “The sole reason for any cooperative’s existence is to serve the needs of its user-members” [USDA, 2011]). As a result, cooperative entry threatens to substantially erode incumbents’ profits, as maintaining existing tacit arrangements becomes challenging, thus driving incumbents to react strongly. On the other hand, investor-owned firms are incentivized to minimize competition and maximize profit, leading to a smaller profit loss for incumbents than when they face cooperative entrants. Moreover, to minimize their potential profit loss, incumbents will show stronger competitive responses to entry by cooperatives than investor-owned firms. Therefore:

H1: Investor-owned incumbents are more likely to respond to entry by cooperatives than entry by investor-owned firms.

4.2.2. Costs of Cooperatives and Intensity of Competition in the Market

This is not to argue that cooperative entrants will always drive incumbents to react more competitively than investor-owned entrants. Cooperatives' unique inherent costs (Boone & Özcan, 2016; Hannsman, 1996; Hart & Moore, 1996, 1998; Jeong et al., 2020) may confine their competitive effects to markets lacking competition.

Unlike starting an investor-owned firm, which requires one or a few like-minded people, starting a cooperative requires a larger number of potential members who share the idea that a cooperative can solve a certain problem (USDA, 2011). Getting such a large group of people to communicate effectively, reach a consensus on cooperative solutions, and engage in a common set of actions is costly (Luo & Kaul, 2019; Ostrom, 1990; Ostrom & Ostrom, 1971).

Moreover, unlike investor-owned firms that pursue a clear goal of maximizing profit, diverse interests among many cooperative owners can incur costs, leading to inefficient decision-making. While democratically elected boards of directors have the authority to make major decisions, the directors may discuss with members before making decisions. With a large number of members, this process requires prolonged timeframes and is susceptible to unpredictable delays. Sometimes the voluntary nature of cooperatives makes it challenging to maintain a sufficient level of attention and support from members/owners (USDA, 1980). If all members/owners are to participate effectively in the decision-making, many members/owners require substantial duplication of effort in providing information about the operations of a cooperative.

However, the monitoring efforts of any individual member/owner have the characteristics of a public good for the owners as a group because all other owners enjoy the benefits of the monitoring, even if they do not monitor at all. As a result, as the number of owners grows, each owner's share of the potential gains from effective monitoring decreases, reducing the individual's incentive to monitor (Hansmann, 1996). Such inefficiencies can hamper cooperatives' abilities to quickly scale and serve more members.

These unique costs of cooperatives imply that they may not be a credible threat in markets with intense competition, where multiple firms force each other to behave as competitively as possible in providing high-quality services at a competitive price. On the other hand, in markets with a lower level of competition where firms are not incentivized to offer high-quality service at a low price, cooperative entry will be a substantial threat. In markets with limited competition, indicated by fewer high-quality providers, cooperative entrants will increase the intensity of competition by offering higher-quality services than investor-owned firms in markets with limited competition. This will lead incumbents to show much stronger responses to cooperative entry than to investor-owned firm entry. Therefore:

H2: The greater the existing competition in the incumbent's market, the smaller the difference in its probability of response to cooperative entry versus investor-owned entry.

4.2.3. Incumbents' Multi-Market Presence

While incumbents may perceive cooperative entry as a larger threat than investor-owned firm entry, their ability and incentive to react are likely moderated by the incumbents' multi-market presence. Firms that cover many markets are likely to have more resources, easier access to resources, lower costs of upgrading existing technology based on previous experiences in other markets, and fewer financial constraints than local firms that cover only a limited region (Greve, 2011; Skiti, 2020a). Such advantages of firms with multi-market presence will allow them to effectively react to entry to stop entrants from expanding their services or entering their other markets.

Moreover, firms covering a larger number of geographic markets face more multi-market competition across the United States than small local firms. Such a broad multi-market presence may incentivize firms to build a reputation for strongly responding to entry, which may help deter entry in their other markets. The more markets a firm covers, the more it will benefit from such a reputation. For firms covering small local regions, the benefits of fighting entry are limited to the small local market they serve (Milgrom & Roberts, 1982; Simon, 2005). For example, a local firm upgrading its technology when facing an entrant in its market may deter future entrants or discourage the further expansion of the entrant in the market. On the other hand, if AT&T aggressively upgrades its technology when facing an entrant in any market they serve, a reputation for aggressively reacting to entry will deter new entrants in other markets that AT&T covers.

As cooperatives' broadband provision has expanded across the United States and more broadband cooperatives have formed in recent years, building a reputation for aggressively deterring cooperative entrants may have benefits in multiple markets the incumbent serves.

Big firms' aggressive responses to cooperative entry have been reported in several case studies. Amidst general opposition from incumbents, big firms like Frontier and CenturyLink offered the most aggressive opposition when residents tried to start broadband cooperatives. Managers from Frontier and CenturyLink intervened in local town meetings, spreading doubt among local residents by arguing that the case for starting a broadband cooperative was based on lies; the plan was certain to fail; residents would have to pay a lot more than promised; the county would go bankrupt; and their existing copper DSL line could perform as well as the fiber optics that the cooperative planned to build. This tactic successfully dissuaded one county from joining a new cooperative (Carlson & Mitchell, 2016).

In another case where local residents tried to switch their Internet subscription to a newly offered fiber Internet service provided by a local cooperative, residents faced a similar pattern of responses from a large incumbent. Frontier made the switching process difficult and expensive by putting consumers on hold for up to an hour and then asking them to pay $250–300 early termination fees. Consumers had not been aware of such fees, as Frontier claimed that the firm had automatically renewed the contract—a contract that the firm does not retain a copy to show consumers when asked. Ultimately, such tactics slowed down the expansion of service provision by the cooperative (Mitchell & Gonzalez, 2014). While technology upgrade cannot capture all the aggressive tactics used by big incumbents in response to cooperative entry, it is expected to capture part of their responses.

An opposite argument is often raised: firms competing in multiple markets are thought to be less likely to compete intensively with each other (Edwards, 1955; Gimeno & Woo, 1999), and multi-market competition even facilitates the tacit coordination and mutual understanding that reduces rivalry (Baum & Korn, 1996; Scott, 1993). Indeed, such phenomena have often been reported among the big providers (e.g., AT&T, Frontier, Charter, Comcast, CenturyLink, Verizon) that together cover more than half of the United States. These firms avoid competition by minimizing overlaps in their service areas (Holmes & Zubak-Skees, 2015; Trostle & Mitchell, 2020).

However, this is not the case for competition between big national providers and small providers such as cooperatives. Mutual forbearance among multi-market competitors is expected only when a rival's expected retaliation in other markets is severe enough to reduce a provider's motivation to respond aggressively, and forbearance is thus expected to be mutual (Chen, 1996; Feinberg, 1984). Due to the substantial difference in market size between the big national providers and cooperatives, the big providers will not perceive cooperatives' potential retaliation in a limited number of other markets as a threat and thus will not reduce the intensity of competitive responses. Moreover, as previously mentioned, formed and operating under a different principle from investor-owned firms, cooperatives are unlikely to come to a mutual understanding with big firms, and thus forbearance would not be expected to be mutual. Therefore:

H3: The greater the number of markets in which an incumbent is present, the greater the difference in its probability of response to cooperative entry versus investor-owned entry.

4.3. Empirical Background

As previously mentioned, the U.S. broadband industry is an ideal setting to test the above arguments for four reasons.

First, while investor-owned providers are the dominant service providers, a growing number of alternative organizational forms—cooperatives and municipal governments—have started or expanded their service coverage. As a result, investor-owned incumbents face entries by heterogeneous organizational forms in numerous geographic markets. Second, because broadband services are geographically bounded, geographic markets are a relatively accurate boundary to define the availability of service options for consumers and the intensity of competition among providers (i.e., consumers usually do not travel to use broadband service, and broadband service providers covering distant areas do not directly compete).

Third, the FCC has strictly enforced mandatory filing on almost every ISP[37] in the United States since 2014 to closely evaluate Internet deployment. These regulations generate population data, which eliminates potential sampling bias. Finally, Internet services are relatively uniform and vary mainly in terms of quality, which allows for

[37] All facilities-based Internet providers are required to file the FCC Form 477 biannually (June and December) at the census block level if their service speed exceeds 0.2 Mbps. The 0.2 Mbps threshold is a very slow speed, given that checking email or browsing the web requires a minimum of 1–5 Mbps. This means that FCC collects data if there is any Internet connection, even if the quality is so poor.

comparison of service quality (see Table 1 and Figure 1) and measurement of quality improvements.

4.3.1. Digital Divide, Limited Competition, and Consumer Cooperatives

As Table 1 and Figure 1 illustrate, Internet quality, measured by speeds, varies substantially based on the type of deployment technology. While certain types of DSL cannot satisfy the current definition of broadband, fiber-to-the-end-user and terrestrial fixed wireless can provide the highest symmetric upload and download speeds. Because more advanced technologies and high-quality Internet deployments (e.g., fiber-to-the-end-user) require sizable investment, without sufficient financial incentives or competition, investor-owned providers are not incentivized to upgrade their technology.

Table 10a. Competition in High-Tech (Fiber and Terrestrial Fixed Wireless) Internet Service Industry

# of *Fiber-to-the-end-user* or *Terrestrial Fixed-Wireless* providers	# of census blocks	%
0	6,155,134	22.01
1	9,923,483	35.49
2	6,808,816	24.35
more than 2	5,074,341	18.15
Total	27,961,774	100

Note. Generated using 2018 FCC data.

Table 10b. Competition in High-Tech (Fiber) Internet Service Industry

# of *Fiber-to-the-end-user* providers	# of census blocks	%
0	16,398,127	58.64
1	8,858,659	31.68
2	2,119,941	7.58
more than 2	585,047	2.09
Total	27,961,774	100

Note. Generated using 2018 FCC data.

Tables 10a and 10b show that many people do not have access to high-tech Internet service in the United States. Approximately 22% of all census blocks in the United States do not have Internet service provided via fiber-to-the-end-user or terrestrial fixed wireless, and 58.6% do not have Internet service provided via fiber-to-the-end-user. These statistics show that as Internet deployment technologies advance, many people do not reap the benefits but instead are left behind with outdated, low-quality Internet services, as frequently reported by the media (Ali, 2019; Halpern, 2019) and academia (DiMaggio et al., 2001; DiMaggio et al., 2004; Greenstein, 2019; Greenstein & Prince, 2006).

Moreover, people with access to high-tech Internet services have no or limited choice. Table 10a shows that 35.5% of all census blocks in the United States have no option to switch providers, and 24.4% have only one option if they want to subscribe to fiber-to-the-end-user or terrestrial fixed wireless. Table 10b shows that 31.7% of all census blocks in the United States do not have any option because there is only one provider, and only 7.6% have one option if they want to use fiber-to-the-end-user quality Internet service.

The lack of competition between providers is problematic. It means firms are not incentivized to satisfy customer needs. According to the American Customer Satisfaction Index (ACSI, 2019),[38] which measures customer satisfaction across 46 industries, ISPs represented by the 12 biggest firms (all investor-owned) remain at the bottom of the

[38] The American Customer Satisfaction Index (2019) uses data from interviews with roughly 300,000 customers annually to analyze customer satisfaction across more than 400 companies in 46 industries and 10 economic sectors.

ACSI rankings among all the industries they measure because the "service is largely considered to be slow and unreliable, and competition is limited in many areas."

Table 11. Total Number of Entries and % of High-Tech Entries by Organizational Forms During 2015–2018

Entry year	Cooperative entry			Investor-owned firm entry			Municipal government entry		
	Entry with high-tech	%	Total entry	Entry with high-tech	%	Total entry	Entry with high-tech	%	Total entry
2015	702	85%	828	27,776	32%	87,486	223	54%	412
2016	779	94%	828	37,943	55%	68,518	137	86%	159
2017	513	89%	578	48,512	61%	79,362	180	98%	184
2018	1,031	96%	1,070	34,200	79%	43,494	81	74%	110
Total	3,025	92%	3,304	148,431	53%	278,860	621	72%	865

Note. Generated using FCC data from 2014 to 2018.

In the meantime, consumer cooperatives increasingly offer Internet services in communities underserved by investor-owned providers (Jeong et al., 2020), especially with high-tech. Table 11 shows that from 2015 to 2018, approximately 92% of cooperative entries were high-tech, while only 53% of investor-owned firm entries were high-tech. As a result, the incumbents face growing competition from cooperatives entering with higher-quality services than the incumbents, making the U.S. broadband industry an excellent setting to study investor-owned incumbents' responses to entry by cooperatives.

4.3.2. Competing on Quality

Multiple studies have reported that incumbents are incentivized to cut prices in response to entry (Bresnahan & Reiss, 1991; Joskow et al., 1994; Simon, 2005; Thomas, 1999; Yamawaki, 2002). However, incumbents are not limited to reacting to new entries only using price and may use other means (Geroski, 1995; Simon, 2005; Skiti, 2020b). The incentive to cut prices weakens in more differentiated product markets because demand is more elastic regarding qualities other than price. In such situations, incumbents are likely to react strongly with means other than price (Gruca et al., 1992), such as quality (Table 1 and Figure 1).

Price is an essential factor for consumers when choosing Internet subscriptions. However, because the Internet is a general-purpose technology that supports numerous critical activities in the modern-day economy, consumer demands are likely to be as elastic in quality as in price. While capturing incumbents' responses to entry using pricing and quality improvements would be ideal, to my knowledge, comprehensive Internet subscription pricing data is unavailable. Therefore, this study uses quality improvements or technology upgrades to measure incumbents' competitive response, which can be observed from the FCC data.

4.4. Data, Methodology, and Variables

4.4.1. Data

I use a dataset on the U.S. fixed broadband industry from the FCC to test these hypotheses. As discussed in the previous chapter, all facilities-based Internet providers are required to file FCC Form 477 biannually (June and December) at the census block level if their service speed exceeds 0.2 Mbps.[39] These data provide detailed information on the names of ISPs, the upload and download speeds they offer, and the Internet deployment technology they use. I collect the December data from 2014 to 2018,[40]

[39] This would be an unusable Internet speed: checking email or browsing the web requires a minimum of 1–5 Mbps. It means the FCC collects data if there is any Internet connection, even if the quality is poor.
[40] I include the data from December 2014, when data filing became mandatory and administered centrally by the FCC. Before December 2014, state entities collected similar data for the SBI and the NTIA, resulting in reporting inconsistencies, especially for cooperatives.

forming a dataset that range from the earliest available year to the most recent available year at the time of the analysis.

I define a geographic market as a census tract because the census tract is the most granular level of geographic resolution with available American Community Survey data provided by the U.S. Census. American Community Survey data is necessary for accessing the characteristics of geographic markets where cooperatives and investor-owned firms enter. Thus, I aggregate the data at the census tract level, although the FCC data is available at the census block level.

To categorize ISPs' organizational forms as investor-owned firms, municipal government, and consumer cooperatives, I manually search for ISPs and triangulate information with several other sources, such as providers' websites, the University of Wisconsin's Cooperative Census, the Institute for Local Self-Reliance's list of Cooperatives Build Community Networks, and the White House's list of U.S. municipalities with broadband networks.[41] In doing so, I identify 2,044 unique investor-owned firms, 327 cooperatives, and 154 municipal governments that filed with the FCC during this period across the United States. I also use U.S. Census data for various demographic variables. Matching the FCC data with the census data yields 2,187,182 census tract ISP-year observations.

4.4.2. Methodology

The hypotheses compare incumbents' responses to cooperative entry and investor-owned firm entry with two moderating effects. It is challenging to compare incumbents' responses to cooperative entry and investor-owned firm entry because

[41] Accessed at https://files.eric.ed.gov/fulltext/ED584128.pdf

cooperatives are more likely to enter areas where investor-owned firms provide low-quality services under certain conditions—more rural, lower income, and socially cohesive communities, as the previous chapter shows. In other words, investor-owned incumbents' responses to cooperative entry are likely to be endogenous, with factors affecting cooperatives to enter certain geographic markets in the first place.

To mitigate this concern, I use CEM to match geographic markets on the conditions reported to predict service coverage by cooperatives, other various demographic characteristics, and focal and neighboring market competitions. Then, I estimate the effect of cooperative entry compared to investor-owned firm entry with a panel event study—a difference-in-differences approach allowed the treatment and outcome to vary over time. This approach effectively compares changes in incumbents' tech upgrades each year before and after the entry is made. Unlike an older application of difference-in-differences or two-way fixed-effect methods, a panel event study is less prone to bias when there are treatment effects heterogeneity and variation in treatment timing (e.g., Athey & Imbens, 2018; Callaway & Sant'Anna, 2020; Goodman-Bacon, 2021; Sun & Abraham, 2020).

In addition, as cooperatives are more comparable to small local investor-owned firms than to national investor-owned firms (e.g., AT&T), including the size of their geographic markets and resources, I compare incumbents' reactions to cooperative entry and local investor-owned firm entry. National investor-owned firms are defined as the seven largest firms that provide Internet services across the United States: AT&T, Frontier, Charter, Comcast, CenturyLink, Verizon, and Windstream. These seven firms cover approximately 55% of all census blocks in the United States.[42] I define local investor-owned ISPs as the remaining investor-owned ISPs because they cover smaller and more local markets than the seven largest firms.

I first exclude census tracts where more than one entry was made in 2015–2018[43] to isolate incumbents' responses to only one entry made during that period. I limit the sample to census tracts where only one cooperative entry or local investor-owned entry was made during 2015–2018, leaving 122,065 observations. Cooperatives can legally enter broadband markets and compete with investor-owned firms, as the Telecommunications Act of 1996 allows any communications business to compete in any market against any other,[44] and cooperatives made a new entry in 36 states in 2015–2018. To match markets where cooperatives entered and markets where local investor-owned firms entered within similar state-level environments, I limit the sample to the 22 states[45] where only one entry was made by cooperatives during the period, reducing the observations to 57,255.

I then match census tracts with only one entry by a cooperative in 2015–2018 (treated group) and the census tracts with only one entry by a local investor-owned firm (control group) during the same period using 17 variables, including the variables used in predicting cooperative emergence in the previous study (Jeong et al., 2020). Those variables were: rural rate, median household income, ethnic diversity, % immigration,

[42] This percentage is based on the number of census blocks in which these firms provide services, using FCC fixed broadband data from 2018 covering all 50 states and Washington, D.C.
[43] I cannot determine whether an entry was made in 2014 because I did not include data from the previous year.
[44] While several states have various barriers for municipal governments entering the broadband market, cooperatives are not subject to these barriers. Cooperatives are incorporated firms, just like investor-owned firms, but are owned by a different group of people, such as consumers.
[45] AK, AL, CA, CO, GA, IA, IL, IN, KY, MN, MO, MT, NC, ND, NE, NM, OR, SC, SD, TN, TX, and WI.

population, unemployment rate, age over 65, bachelor or higher, % Native American, municipal government, number of investor-owned providers, and areas covered by business services. As competition in neighboring geographic markets can affect entry and incumbents' responses in a focal geographic market, I also match the number of providers by organizational forms in the neighboring geographic market—the average number of municipal government providers, the average number of cooperative providers, and the average number of investor-owned providers in neighboring census tracts. Neighboring geographic markets are defined as census tracts that share a border with a focal census tract. Using the ArcGIS Pro Polygon Neighbors function, I extract census tracts that share the same boundaries to assess neighboring markets (see Appendix 6).

In matching these geographic markets, I used CEM as described by Iacus et al. (2012). Unlike more traditional matching techniques, such as propensity score matching, CEM enables exact multidimensional matching, which prevents any adjustments made to an imbalance on one variable from affecting the maximum imbalance of other variables (King & Nielsen, 2019). While CEM can substantially reduce endogeneity concerns in the same vein as other matching techniques, it cannot control for unobservable factors affecting cooperatives' entry and incumbents' responses at the same time.

Table 12 and Figure 4 show how matching increased the balance between the treated and control groups. As the balance is a characteristic of the observed sample, not of a hypothetical population, using a hypothesis test (e.g., *t*-test) for checking balance is not recommended (Ho et al., 2007). Therefore, I compare the means of two groups over the pooled standard deviation: most variables show significantly more improved balances and negligible differences after matching.

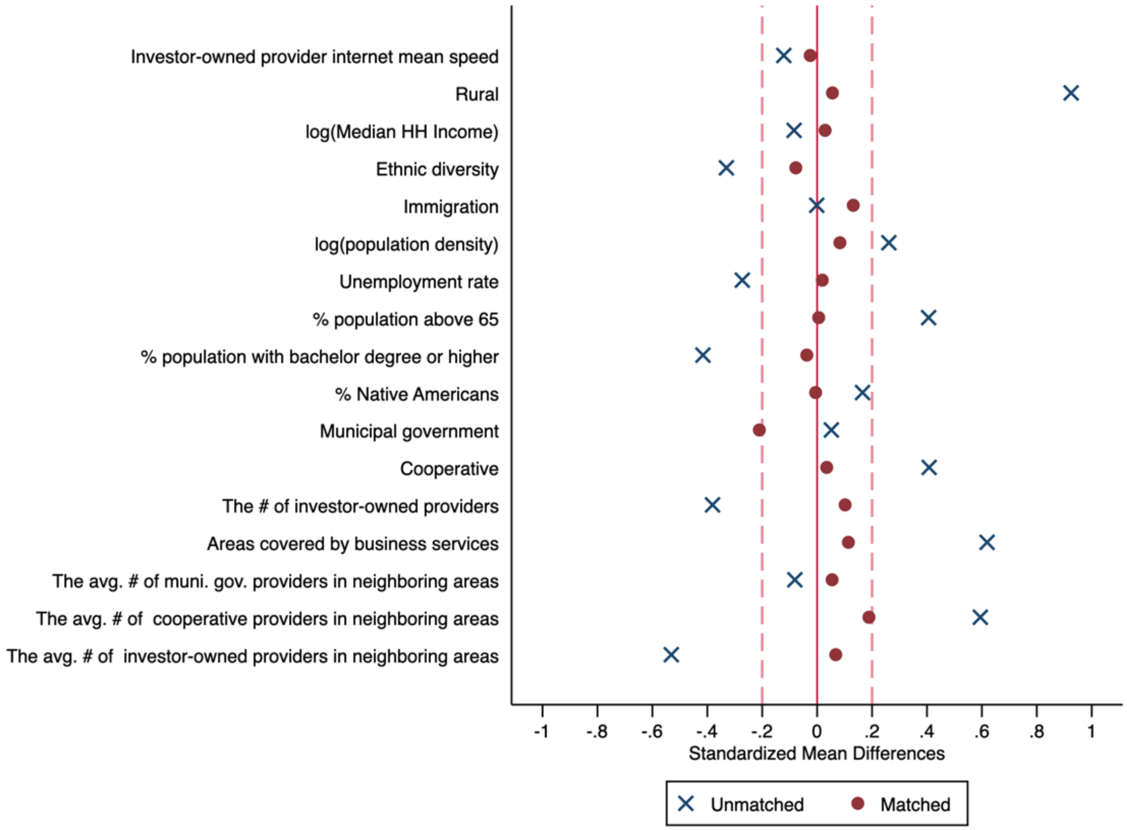
Table 13 shows that the matched sample, on average, has a lower number of overall entries and a lower likelihood of investor-owned firms upgrading to high-tech, while the average number of cooperative entries is higher than the entire sample. The matched sample also shows lower ethnic diversity, a lower immigration rate, and lower population density. The differences between the summary statistics of the entire sample and the matched sample are consistent with the previous findings that cooperatives are more likely to serve areas underserved by investor-owned firms, especially in rural communities and communities with high social cohesion, as measured by ethnic diversity and immigration rate.

Table 12. Assessing Balance 1- Before and After CEM (Standardized Mean Difference)

	before CEM	after CEM
Investor-owned provider internet mean speed	-0.12	-0.03
Rural	0.93	0.06
log(Median HH income)	-0.08	0.03
Ethnic diversity	-0.33	-0.08
Immigration	-0.001	0.13
log(population density)	0.26	0.08
Unemployment rate	-0.27	0.02
% population above 65	0.41	0.01
% population with bachelor degree or higher	-0.42	-0.04
% Native Americans	0.17	-0.01
Municipal government	0.05	-0.21
Cooperative	0.41	0.03
The number of investor-owned providers	-0.38	0.10
Areas covered by business services	0.62	0.11
The avg. # of muni. gov. providers in neighboring areas	-0.08	0.05
The avg. # of cooperative providers in neighboring areas	0.59	0.19
The avg. # of investor-owned providers in neighboring areas	-0.53	0.07

Note. Standardized mean differences (SMDs) are the difference in the means of two groups that are standardized by the pooled standard deviation across both groups. Suggested guidelines for interpreting the magnitude of the SMD: 0.2 = small, 0.5 = medium, and 0.8 = large, meaning if the difference between two groups' means is less than 0.2 standard deviation, the difference is negligible (Cohen, 2013). It should be noted that the number of observations before CEM (*n* = 64,810) is different from the number of observations of the entire sample (*n* = 2,187,182) because I limited the sample to the census tracts where only one cooperative entry or local investor-owned firm entry is made during 2015 to 2018 within the same states before matching.

Figure 4. Assessing Balance 2- Before and After CEM (Standardized Mean Difference)



Note. Standardized mean differences (SMDs) are the differences in the means of two groups standardized by the pooled standard deviation across both groups. Suggested guidelines for interpreting the magnitude of the SMD: 0.2 = small, 0.5 = medium, and 0.8 = large, meaning if the difference between two groups' means is less than 0.2 standard deviation, the difference is negligible (Cohen, 2013).

Table 13. Summary Statistics (Entire Sample & Matched Sample)

	Entire sample				Matched final sample			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Tech upgrade by Investor-owned ISPs	0.44	0.50	0	1	0.34	0.47	0	1
Tech upgrade (Fiber-to-the-end-user) by Investor-owned ISPs	0.29	0.45	0	1	0.13	0.34	0	1
Entry	0.56	0.50	0	1	0.22	0.41	0	1
Entry with high-tech	0.38	0.48	0	1	0.13	0.34	0	1
Treated (coop entry)	0.04	0.21	0	1	0.19	0.40	0	1
Ln(median household income)	10.80	1.17	0	12.43	10.59	1.44	0	11.97
Ethnic diversity	0.40	0.20	0	0.83	0.21	0.18	0	0.76
% immigration from abroad	0.01	0.01	0	1	0.002	0.004	0	0.04
Ln(population density)	3.85	1.74	0	9.11	1.70	1.39	0	8.44
Unemployment rate	0.07	0.05	0	1	0.06	0.04	0	0.35
% population above 65	0.15	0.08	0	1	0.17	0.05	0	0.36
% population with bachelor or higher	0.28	0.19	0	1	0.16	0.09	0	0.71
% Native American	0.01	0.03	0	1	0.01	0.01	0	0.12
Municipal government	0.04	0.20	0	1	0.03	0.18	0	1
# of investor-owned ISPs	7.11	3.18	0	32	4.28	1.88	0	10
Areas covered by business services	1.25	1.46	0	25.77	1.92	1.85	0	15.77
Avg. # of investor-owned ISPs in neighboring areas	6.72	2.32	0	25.75	4.63	1.65	0	12
Avg. # of muni. gov. ISPs in neighboring areas	0.04	0.17	0	3	0.04	0.12	0	1
Avg. # of cooperative ISPs in neighboring areas	0.12	0.40	0	7	0.38	0.49	0	2.57

Table 14. Correlation (Matched Sample)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Tech upgrade by Investor-owned ISPs	1																		
2	Tech upgrade (Fiber only) by Investor-owned ISPs	0.55	1																	
3	Entry	0.01	-0.01	1																
4	Entry with high-tech	0.10	0.02	0.73	1															
5	Treated (coop entry)	-0.01	0.02	-0.004	0.08	1														
6	Ln(median household income)	-0.13	0.04	-0.04	-0.08	0.04	1													
7	Ethnic diversity	-0.05	0.03	0.01	-0.06	-0.02	0.11	1												
8	% immigration from abroad	0.02	0.03	0.02	0.03	0.09	0.07	0.20	1											
9	Ln(population density)	-0.03	0.05	0.005	-0.05	-0.09	0.17	0.52	0.20	1										
10	Unemployment rate	-0.15	-0.05	-0.04	-0.09	0.10	0.12	0.28	0.05	0.08	1									
11	% population above 65	-0.08	0.01	-0.02	-0.02	-0.002	0.41	-0.21	-0.06	-0.26	-0.03	1								
12	% population with bachelor or higher	0.03	0.10	0.06	0.003	-0.06	0.36	0.18	0.20	0.44	-0.22	0.07	1							
13	% Native American	-0.02	0.03	-0.003	-0.01	0.02	0.03	0.24	0.04	0.03	0.16	0.05	-0.05	1						
14	Municipal government	-0.03	-0.04	-0.01	0.02	-0.09	0.02	-0.08	-0.04	-0.06	0.05	-0.03	-0.04	-0.07	1					
15	# of investor-owned ISPs	0.11	0.01	0.03	0.003	-0.03	0.23	-0.20	-0.02	0.04	-0.06	0.02	0.11	-0.17	-0.03	1				
16	Areas covered by business services	-0.02	-0.004	0.004	0.03	0.10	0.17	-0.31	-0.03	-0.29	-0.23	0.22	0.03	0.06	-0.03	0.09	1			
17	Avg. # of investor-owned ISPs in neighboring areas	0.11	0.02	0.01	0.01	0.03	0.35	0.06	0.13	0.33	-0.03	-0.03	0.31	-0.14	-0.01	0.71	0.01	1		
18	Avg. # of muni. gov. ISPs in neighboring areas	-0.04	-0.04	0.01	0.04	-0.05	0.003	-0.06	0.03	-0.11	0.05	-0.02	-0.05	-0.06	0.56	-0.06	-0.07	-0.07	1	
19	Avg. # of cooperative ISPs in neighboring areas	-0.10	-0.03	0.02	0.05	0.23	0.11	-0.28	-0.05	-0.32	-0.14	0.28	-0.02	0.02	-0.01	-0.24	0.55	-0.26	0.002	1

Next, the effect of having a cooperative entry compared to an investor-owned firm entry on incumbents' technology upgrades are estimated on the matched sample, using the following panel event study model:

$$(1) \qquad TechUpgrade_{ict}=\alpha_0+\sum_{j=-3,\, j\neq-1}^{3} \delta_c\, 1(t\text{-}T_c=j)*Treated+ X_{st}\gamma + ctISP_{ic} + stateyear_{st} + \varepsilon_{ist}$$

where $TechUpgrade_{ict}$ is a binary variable indicating whether an incumbent ISP i has upgraded to high-tech in census tract c at time t. 1( ) indexes years relative to the year when entry is made in the census tract, T_c, such that each δ_c coefficient represents the interaction with the Treated group in the relative year j. For example, j = 1 refers to a year after an entry is made. Event periods 2 and 3 years prior to entry were combined into a single bin, as were event periods 2 and 3 years after entry. Such aggregation follows prior literature (e.g., Kline, 2012) in addressing sample size imbalances created by differences in the timing of entries. Incumbents intent to deter the entrants' expansion are expected to act immediately after learning about entry, upgrading their technology the same year or a year after the entry is made. In other words, the effect of treatment(entry) will wear off after 1 year, and for this reason, I focused on the event time 0 and 1.

As a standard practice, the baseline is 1 year prior to entry, which is omitted in tables and figures. X_{ct} is a vector of controls for census tract c at time t. I also included $ctISP_{is}$, a census tract-ISP fixed effect that captures time-invariant unit level differences, and $stateyear_{st}$, a set of state-year fixed effects that captures time-varying changes in state, including state policies or legal environments that may affect cooperative entry. This model estimates the difference in incumbents' tech upgrade for leads and lags of entry in census tracts where cooperatives entered relative to a baseline year (event time -1) and relative to census tracts where local investor-owned firms entered. The relative differences are captured by the coefficients δ_c.

4.4.3. Variables

Dependent variable. I measure *Technology upgrade* as a dummy variable indicating whether an incumbent ISP upgrades its technology to high-tech. High-tech is defined as fiber-to-the-end-user and terrestrial wireless, as they provide the highest symmetric upload and download speeds among all technologies (see Table 1 and Figure 1). For supplementary analyses, I also defined high-tech as fiber-to-the-end-user only because the technology can provide the highest symmetric upload and download speeds.

Independent variable. Entry is a dummy variable indicating whether an entry is made in a geographic market, a census tract. A panel event study approach allows comparing changes in incumbents' technology upgrades each year before and after. These are denoted by 3 and 2 years before entry, Entry, 1 year, 2 and 3 years after entry.

Control variables. I include multiple control variables at the census tract level and firm level for time-varying factors that may affect entries by cooperatives or local investor-owned firms and incumbents' responses to their entry. Specifically, I include variables used in predicting Internet service provision by cooperatives (Jeong et al., 2020): *Ln (median household income), Ethnic diversity,*[46] *% immigration from abroad, Ln (population density), Unemployment rate, % population above 65, % population with bachelor or higher, % Native American, Municipal government*, *the number of investor-owned providers*, and *Areas with investor-owned biz services.* Additionally, because competition in neighboring census tracts may affect

[46] *Ethnic diversity = 1- ∑i (Racei) , where i = {White, Black, Hispanic, Asian, Native Americans, and Other}* (Alesina & La Ferrara, 2000 ; Alesina et al., 1999; Alesina et al., 2019).

incumbents' responses to entry, I also include variables measuring competition in neighboring census tracts: *Avg. number of investor-owned ISPs in neighboring areas, Avg. number of muni. gov. ISPs in neighboring areas,* and *Avg. number of cooperative ISPs in neighboring areas.*

4.5. Results

4.5.1. Descriptive Statistics

Before testing the main predictions with regression analyses on differences in entry responses (high-tech upgrades) between markets facing cooperative entry (treated group) and markets facing investor-owned firm entry (control group), it is helpful to discuss the two findings from the descriptive statistics, Figures 5a and 5b.

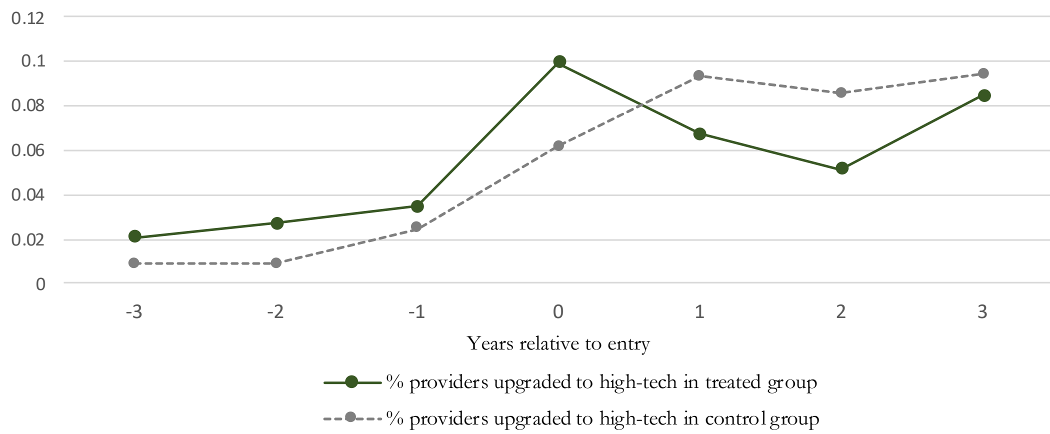
First, the entry responses are shown in the year when entries are made, suggesting that entries are anticipated. Indeed, to start providing Internet service in a certain geographic market, a physical Internet network should be built, which, depending on multiple factors, may take months.[47] The necessity of this time-consuming process before a market entrant can offer Internet service (and thus become recorded in the FCC data) allows incumbents to anticipate entries and prepare for immediate responses.

Second, while incumbents or markets facing cooperative entry are more likely to experience high-tech upgrades than the ones facing investor-owned entry, there are entry responses in both markets. Figure 5a shows that rates of incumbents that upgraded to high-tech jump in the year when entries are made (relative year 0) in markets facing cooperative entry and in markets facing investor-owned entry. Similarly, Figure 5b shows that rates of census tracts

[47] For example, the distance between the backbone and the location of consumers; existing infrastructure such as utility pole and buried conduit that can be reused; different methods of building such as aerial building, underground building (standard trench, micro trench), or even underwater building.

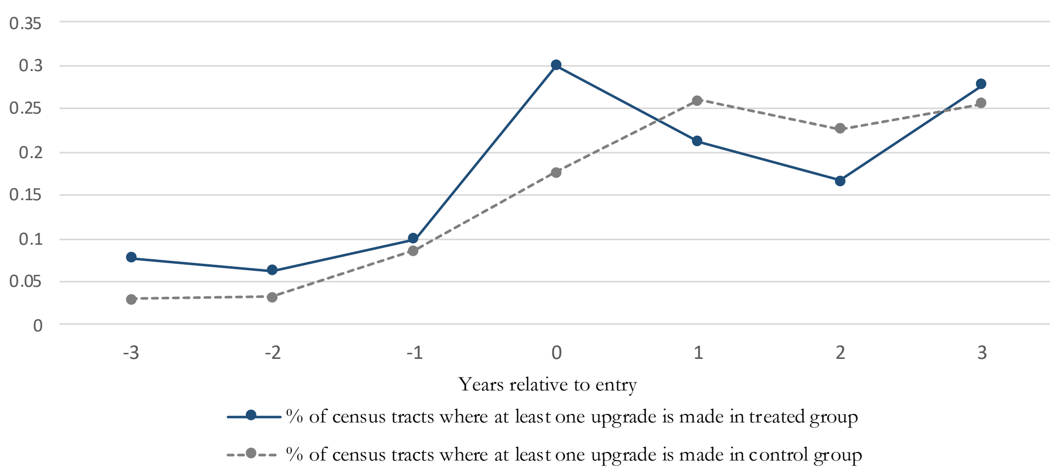
where any high-tech upgrades are made suddenly increase in the year when entries are made in both groups.

Figure 5a. Rates of Census Tract-Incumbents that upgraded to high-tech



Note. Generated using the matched FCC data from 2014 to 2018.

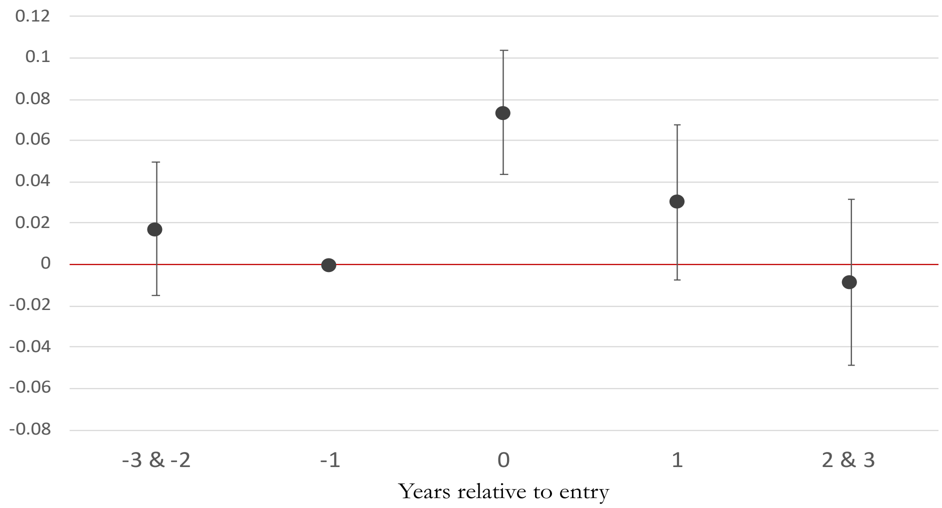
Figure 5b. Rates of Census Tracts Where at Least One Incumbent Upgraded to High-Tech



Note. Generated using the matched FCC data from 2014 to 2018.

4.5.2. Main Findings

Figure 6. The Difference Between Incumbents' High-Tech Upgrades Relative to Cooperative and Investor-Owned Firm Entry and Relative to Reference Year (−1)



Note. Plots the δ_c coefficients in equation (1). As standard, the baseline is 1 year prior to entry. Positive coefficients indicate that incumbents upgrade more in the treated group (markets with cooperative entry) than in the control group (markets with investor-owned firm entry).

Figure 6 plots the δ_c coefficients in equation (1), showing the difference in the likelihood of high-tech upgrades by incumbents facing cooperative entry and incumbents facing investor-owned firm entry relative to the difference in the reference year (−1). The pre-entry δ_c coefficient (at relative years −3 and −2) is statistically indistinguishable from zero, but there is a large and statistically significant increase when entry is made. In other words, incumbents facing cooperative entry are more likely to upgrade to high-tech than incumbents facing local investor-owned firm entry when entry is made. As discussed in the previous section, such early entry responses suggest that entries are anticipated. Building or acquiring a physical network before providing Internet service will inform incumbents about entry and allow them to prepare for immediate responses. Figure 6 illustrates that H1 is supported.

M1 in Table 15 also reports results on H1, including the same coefficients that are plotted in Figure 5. The results show that all else being equal, on average, when cooperatives make entries, the probability of incumbents upgrading to high-tech is 7.3 percentage points higher (β = 0.0733, $p < 0.05$ in the year when entry is made) than when entries are made by investor-owned firms, supporting H1. M2 reports the results using a two-way fixed-effects approach to demonstrate the basic research design approach. While recent difference-in-differences literature has suggested that such a method can bias the estimation when treatment effects are heterogeneous and treatment timing varies (e.g., Athey & Imbens, 2018; Callaway & Sant'Anna, 2020; Goodman-Bacon, 2021; Sun & Abraham, 2020), these particular results show relatively similar coefficients if we consider only the year when entry is made when using the event study estimation (M1 Entry*Treated: $\beta = 0.0733$, $p < 0.05$) compared to when using an older DD approach (M2 Entry*Treated: $\beta = 0.0707$, $p < 0.05$). However, using the panel event study approach helps to understand there was no pre-trend before entry is made and that entry responses are more immediate and short-lasting than gradual and long-lasting.

4.5.3. Moderating Effects of Market Competition and Incumbents' Multi-Market Presence

The average treatment effect of facing cooperative entry compared to local investor-owned firm entry may mask significant heterogeneity. Thus, in this section, I explore the heterogeneous effects of cooperative entry versus investor-owned firm entry on incumbents by splitting the sample in multiple ways and estimating δ_c for the subsamples. First, I investigate the moderating effects of the intensity of market competition, measured by the number of high-tech service providers before any entry was made as shown in Table 16. Second, I examine the role of incumbents' multi-market presence in Table 17.

Table 15. Main Results

	DV: High-tech upgrade by Investor-owned ISPs	
	M1	M2
Entry*Treated		0.0707
		(0.0244)
Years relative to entry		
2 & 3 years before entry*Treated	0.0171	
	(0.5972)	
Entry*Treated	0.0733	
	(0.0153)	
1 year after entry*Treated	0.0303	
	(0.4219)	
2 & 3 years after entry*Treated	-0.00887	
	(0.8257)	
Control variables		
Ln(median household income)	-0.00471	-0.00423
	(0.7901)	(0.8271)
Ethnic diversity	0.362	0.364
	(0.0193)	(0.0561)
% immigration from abroad	-3.689	-3.529
	(0.0987)	(0.2943)
Ln(population density)	0.0693	0.0681
	(0.5824)	(0.6810)
Unemployment rate	0.368	0.371
	(0.1504)	(0.3701)
% population above 65	0.615	0.599
	(0.1705)	(0.1945)
% population with bachelor or higher	0.325	0.326
	(0.1848)	(0.2343)
% Native American	-0.562	-0.556
	(0.6315)	(0.6107)
Municipal government	-0.0902	-0.0881
	(0.0780)	(0.4924)
# of investor-owned ISPs	0.0132	0.0142
	(0.1420)	(0.2658)
Areas covered by business services	0.00142	0.00165
	(0.9164)	(0.9344)
Avg. # of investor-owned ISPs in neighboring areas	-0.0225	-0.0220
	(0.1014)	(0.1724)
Avg. # of muni. gov. ISPs in neighboring areas	0.120	0.124
	(0.2508)	(0.4046)
Avg. # of cooperative ISPs in neighboring areas	0.0343	0.0424
	(0.4807)	(0.4825)
State-Year fixed	yes	yes
Census tract- ISP fixed	yes	yes
Observations	4,037	4,037
Number of ct_isp_id	1,102	1,102
R-squared	0.166	0.166

Note. Estimated on the matched sample, using fixed effect OLS. As standard, the baseline (omitted) is 1 year prior to entry. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses.

Intensity of competition. As presented in Appendix 7a, 21.7% of the sample have no high-tech providers, 30.4% have only one high-tech provider, 23% have two high-tech providers, and 25% have more than two high-tech providers. Because no cooperatives enter the market with more than three high-tech providers, and the overall number of samples with more than three high-tech providers is small (11% of the total sample), I combine markets with more than two high-tech providers instead of looking at them separately.

M3 to M6 in Table 16 report the results on H2. The results show that all else being equal, in the year when entry is made, on average, the probability of incumbents upgrading to high-tech is 15.6 and 17.1 percentage points higher (M4: $\beta = 0.1559$, $p < 0.05$, M5: $\beta = 0.1713$, $p < 0.05$) in markets with only one and two high-tech provider(s), respectively, when facing cooperative entry compared to investor-owned firm entry. In markets with more than two high-tech providers (M6), the incumbents' responses do not show any significant differences when facing cooperative entry compared to local investor-owned entry and the two coefficients (Entry) from M5 and M6 are significantly different with a *p*-value of 0.0477,[48] supporting H2.

[48] The cross-equation tests are based on seemingly unrelated regressions with robust standard error after centering the means of variables by census tract-ISP to estimate fixed effects. Additionally, although the panel event study approach allows the comparison of changes in incumbents' technology upgrades each year before and after, and there are positive and significant results in markets with one high-tech provider one year, two years, and three years after entry, for the convenience of comparing multiple models, I compare coefficients in the year when entry is made throughout the analyses.

Table 16. Moderation Results 1: Market Competition

	DV: High-tech upgrade by Investor-owned ISPs			
	The # of ISPs providing high-tech internet before entry:			
	0	1	2	>2
	M3	M4	M5	M6
2 & 3 years before entry*Treated	0.2238	-0.1045	0.1237	0.0133
	(0.1072)	(0.1460)	(0.0692)	(0.8448)
Entry*Treated	-0.0338	0.1559	0.1713	0.0001
	(0.8003)	(0.0205)	(0.0287)	(0.9990)
1 year after entry*Treated	0.0405	0.1224	0.1173	0.0053
	(0.7484)	(0.0775)	(0.1052)	(0.9589)
2 & 3 years after entry*Treated	-0.0554	0.213	0.0330	-0.1251
	(0.6901)	(0.0719)	(0.6134)	(0.2795)
Test of equality (Entry*Treated)	$p=$ 0.1698	$p=$0.4717	$p=$0.0477	
State-Year fixed	yes	yes	yes	yes
Census tract- ISP fixed	yes	yes	yes	yes
Observations	810	1,211	952	1,064
R-squared	0.178	0.228	0.253	0.228
Number of ct_isp_id	237	332	253	280

Note. Estimated on the matched sample using fixed effect OLS. Control variables—Ln (median household income), Ethnic diversity, % immigration from abroad, Ln (population density), Unemployment rate, % population above 65, % population with bachelor's degree or higher, % Native American, Municipal government, # of investor-owned ISPs, Areas covered by business services, Avg. # of investor-owned ISPs in neighboring areas, Avg. # of muni. gov. ISPs in neighboring areas, Avg. # of cooperative ISPs in neighboring areas—are included. As standard, the baseline (omitted) is 1 year prior to entry. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses. High-tech is defined as fiber-to-the-end-user and terrestrial fixed wireless. The cross-equation tests are based on seemingly unrelated regressions with robust standard error after centering the means of variables by census tract-ISP to estimate fixed effects. Although panel event study approach allows the comparison of changes in incumbents' technology upgrade each year before and after, for the convenience of comparison among multiple models, I compared coefficients in the year when entry is made throughout the analyses.

Table 17. Moderation Results 2: Incumbents' Multi-Market Presence

	DV: High-tech upgrade by Investor-owned ISPs	
	Biggest 7 ISPs	Other ISPs
	M7	M8
2 & 3 years before entry*Treated	0.0129	0.0301
	(0.8343)	(0.4326)
Entry*Treated	0.1286	0.0162
	(0.0369)	(0.3252)
1 year after entry*Treated	0.1095	-0.0443
	(0.1370)	(0.2120)
2 & 3 years after entry*Treated	0.0540	-0.0797
	(0.5351)	(0.0155)
Test of equality (Entry*Treated)	p =0.0630	
State-Year fixed	yes	yes
Census tract- ISP fixed	yes	yes
Observations	1,957	1,669
R-squared	0.272	0.216
Number of ct_isp_id	480	513

Note. Estimated on the matched sample using fixed effect OLS. Control variables—Ln (median household income), Ethnic diversity, % immigration from abroad, Ln (population density), Unemployment rate, % population above 65, % population with bachelor's degree or higher, % Native American, Municipal government, # of investor-owned ISPs, Areas covered by business services, Avg. # of investor-owned ISPs in neighboring areas, Avg. # of muni. gov. ISPs in neighboring areas, Avg. # of cooperative ISPs in neighboring areas—are included. As standard, the baseline (omitted) is 1 year prior to entry. Robust standard errors are clustered at the census tract level. *** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$. High-tech is defined as fiber-to-the-end-user and terrestrial fixed wireless. Largest 7 ISPs: AT&T, Frontier, Charter, Comcast, CenturyLink, Verizon, and Windstream. The cross-equation tests are based on seemingly unrelated regressions with robust standard error after centering the means of variables by census tract-ISP to estimate fixed effects.

Incumbents' multi-market presence. As previously mentioned, the seven big national providers cover the highest number of geographic markets, covering 55% of the United States and the rest cover much smaller local markets. M7 in Table 17 reports that the difference between these seven biggest providers' responses to cooperative entry and local investor-owned firm entry becomes significantly different when entries are made (M7: $\beta = 0.129$, $p < 0.05$). On the other hand, the other smaller providers do not show any significant difference in the year when entry is made and then show negative differences at the endpoint (2 and 3 years after entry). This suggests that small incumbents are less likely to upgrade their technology when facing cooperative entry than local investor-owned firm entry. The two coefficients (Entry*Treated) from M7 and M8 show a marginally significant difference with a p-value of 0.063.

4.5.4. Robustness Check and Supplementary Analyses

Entry with high-tech only. Because previous models do not specify the type of technology (high-tech, low-tech) that entry is made with, it is possible that the previous results are capturing the incumbents' responses to high-tech cooperative entry and low-tech investor-owned firm entry, showing the incumbents' reaction to match what entrants bring with them. This is consistent with the argument that incumbents facing cooperatives are more likely to upgrade to high-tech to match their technology than incumbents facing investor-owned firms since cooperatives are more likely to enter with high-tech than investor-owned firms.

However, in such a case, it is challenging to argue that incumbents' responses are driven by cooperatives' unique characteristics of countering market power compared to investor-owned firms. As previously discussed, I predict that incumbents are more likely to react to cooperative entry than investor-owned firm entry because cooperative entrant will be a bigger threat than investor-owned firms for two main reasons. First, cooperatives are unlikely to share mutual understanding with incumbents as cooperatives are formed to prioritize member/consumer benefits, while investor-owned firms are likely to minimize competition to maximize profits. Second, greater consumer trust and loyalty come from consumer ownership and a democratic system that allows cooperatives to attract consumers from incumbents.

To exclude the case where the results are simply driven by incumbents upgrading to high-tech to match with entrants' technology level, I run analyses using the sample where entries are made with high-tech only.[49] If incumbents still show stronger responses to cooperative entry than to investor-owned firm entry, such results may be attributed to cooperatives' unwillingness to have a mutual understanding with incumbent investor-owned firms and their advantages in attracting consumers with consumer ownership and a democratic system.

Table 18 shows the results are consistent with the previous findings. Even when entries are made with the same high-tech, incumbents will show stronger reactions to cooperative entry than to investor-owned firm entry. M9 in Table 18 shows that all else being equal, on average, when entries are made by cooperatives, the probability of incumbents upgrading to high-tech is 11.9 percentage points higher ($\beta = 0.119$, $p < 0.05$ in the year when entry is made) than when entries are made by investor-owned firms, again supporting H1.

[49] As there is an insufficient number of cooperatives entering with low-tech, the same analysis using only low-tech entry could not be conducted.

M10–M13 in Table 18 further test the H2 on moderating effects of market competition, using entry with high-tech only. The results show that all else being equal, in the year when entry is made, on average, the probability of incumbents upgrading to high-tech is 26.2 percentage points higher (M11: $\beta = 0.262$, $p < 0.05$) when facing cooperative entry compared to investor-owned firm entry in markets with only one high-tech provider. While incumbents in markets with two high-tech providers show only a marginally significant difference between when facing cooperative entry and facing investor-owned firm entry, the two coefficients (Entry*Treated) from M11 and M12 do not show a significant difference with a p-value of 0.7703, suggesting the two coefficients are not different. Consistent with the previous results, M13 shows that the incumbents' responses do not show any significant differences when facing cooperative entry compared to local investor-owned entry in markets with more than two high-tech providers. The test of equality also shows that the coefficient on the two coefficients (Entry*Treated), M12 and M13, is significantly different, with a p-value of 0.0073, again supporting H2.

M14 and M15 in Table 18 report the results for H3 on moderating effects of incumbents' multi-market presence, using entry with high-tech only. The difference between these seven largest providers' responses to cooperative entry and local investor-owned firm entry becomes significantly different when entries are made (M14: $\beta = 0.202$, $p < 0.05$); all else being equal, on average, the probability of the seven largest providers upgrading to high-tech is 20.2 percentage points higher (M11: $\beta = 0.202$, $p < 0.05$) when facing cooperative entry compared to investor-owned firm entry in the year when entry is made. Consistent with the previous results using all technology types, other smaller providers do not show any significant difference in the year when entry is made. The two coefficients (Entry*Treated) from M14 and M15 show a significant difference with a *p*-value of 0.0184, supporting H3.

High-tech as fiber-to-the-end-user only. As previously discussed, fiber-to-the-end-user is the most advanced technology that can provide the highest symmetric download and upload speeds (see Figure 1) and is only deployed in about 11% of the United States. Despite such a small portion of fiber-to-the-end-user deployment, I run an analysis using fiber-to-the-end-user as a high-tech to see whether the results show the same patterns.

Table 19 reports that while the results are consistent with the previous findings where terrestrial fixed wireless and fiber-to-the-end-user are defined as high-tech, the overall significance of the results is reduced. M16 in Table 19 reports that the difference between incumbents facing cooperative entry and investor-owned firm entry is now marginally significant (M16: $\beta = 0.0503$, $p < 0.1$). Moreover, the moderating effect of market competition shows a significant difference in markets with only one high-tech Internet provider (M18: $\beta = 0.108$, $p < 0.05$). The incumbents in markets with two or more high-tech providers did not show any significant differences between facing cooperative entry and facing investor-owned firm entry. Furthermore, the two coefficients (Entry*Treated) from only one high-tech provider (M18) and two high-tech providers (M19) show a marginally significant difference with a *p*-value of 0.055. Finally, M21 and M22 show that the difference between the seven largest firms and other smaller firms becomes not significant.

Table 18. Robustness Check: Entry with High-Tech Only

	DV: High-tech upgrade by Investor-owned ISPs						
	Main	Subsample analyses 1: the # of ISPs providing high-tech internet before entry:				Subsample analyses 2:	
		0	1	2	>2	Biggest 7 ISPs	Other ISPs
	M9	M10	M11	M12	M13	M14	M15
2 & 3 years before entry*Treated	0.0605	0.305	-0.120	0.115	-0.124	0.0526	0.0104
	(0.2777)	(0.2396)	(0.5136)	(0.4299)	(0.3931)	(0.5608)	(0.8854)
Entry*Treated	0.119	-0.207	0.262	0.260	-0.165	0.202	0.00186
	(0.0430)	(0.3362)	(0.0288)	(0.0625)	(0.3242)	(0.0302)	(0.9663)
1 year after entry*Treated	0.134	-0.190	0.237	0.0369	-0.147	0.232	0.00421
	(0.0378)	(0.5092)	(0.0444)	(0.8118)	(0.4568)	(0.0397)	(0.9290)
2 & 3 years after entry*Treated	0.117	-0.264	0.542	-0.138	-0.346	0.196	0.0336
	(0.1783)	(0.3724)	(0.0208)	(0.4855)	(0.0905)	(0.1547)	(0.4103)
Test of equality (Entry*Treated)		$p = 0.0988$	$p = 0.7703$	$p = 0.0073$		$p = 0.0184$	
State-Year fixed	yes	yes	yes	yes	yes	yes	yes
Census tract- ISP fixed	yes	yes	yes	yes	yes	yes	yes
Observations	3,206	481	962	785	978	1,371	1,434
Number of ct_isp_id	839	146	254	196	243	290	432
R-squared	0.166	0.306	0.219	0.220	0.221	0.324	0.237

Note. Estimated on the matched sample, using fixed effect OLS. Control variables—Ln (median household income), Ethnic diversity, % immigration from abroad, Ln (population density), Unemployment rate, % population above 65, % population with bachelor's degree or higher, % Native American, Municipal government, # of investor-owned ISPs, Areas covered by business services, Avg. # of investor-owned ISPs in neighboring areas, Avg. # of muni. gov. ISPs in neighboring areas, Avg. # of cooperative ISPs in neighboring areas—are included. As standard, the baseline (omitted) is 1 year prior to entry. Robust standard errors are clustered at the census tract level. *** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$. High-tech is defined as fiber-to-the-end-user. The cross-equation tests are based on seemingly unrelated regressions with robust standard error after centering the means of variables by census tract-ISP to estimate fixed effects.

Table 19. Supplementary Analysis: High-Tech as Fiber-to-the-End-User Only

	DV: High-tech (Fiber only) upgrade by Investor-owned ISPs						
	Main	Subsample analyses 1. the # of ISPs providing high-tech internet before entry:				Subsample analyses 2. biggest 7 ISPs vs. others	
		0	1	2	>2	Biggest 7	Others
	M16	M17	M18	M19	M20	M21	M22
2 & 3 years before entry*Treated	0.00996	0.0706	-0.0165	-0.162	1.271	0.0161	0.0220
	(0.6761)	(0.0202)	(0.7528)	(0.5081)	(0.1067)	(0.7452)	(0.5479)
Entry*Treated	0.0503	0.00681	0.108	0.00705	1.797	0.0994	0.0165
	(0.0599)	(0.8891)	(0.0137)	(0.9612)	(0.1319)	(0.0747)	(0.4159)
1 year after entry*Treated	0.00534	0.00512	0.0884	0.169	1.837	0.0480	-0.0332
	(0.8723)	(0.9234)	(0.1066)	(0.4654)	(0.1709)	(0.3584)	(0.3966)
2 & 3 years after entry*Treated	-0.0296	0.00779	0.0106	0.0868	1.871	-0.0188	-0.0676
	(0.4070)	(0.9389)	(0.8321)	(0.7026)	(0.1699)	(0.7698)	(0.1123)
Test of equality (Entry*Treated)		p=0.0603	p=0.055	p=0.0000		p=0.1267	
State-Year fixed	yes	yes	yes	yes	yes	yes	yes
Census tract- ISP fixed	yes	yes	yes	yes	yes	yes	yes
Observations	5,280	2,420	1,880	779	201	1,957	1,669
R-squared	0.135	0.178	0.148	0.252	0.314	0.248	0.222
Number of ct_isp_id	1,385	648	501	191	45	480	513

Note. Estimated on the matched sample, using fixed effect OLS. Control variables—Ln (median household income), Ethnic diversity, % immigration from abroad, Ln (population density), Unemployment rate, % population above 65, % population with bachelor's degree or higher, % Native American, Municipal government, # of investor-owned ISPs, Areas covered by business services, Avg. # of investor-owned ISPs in neighboring areas, Avg. # of muni. gov. ISPs in neighboring areas, Avg. # of cooperative ISPs in neighboring areas- are included. As standard, the baseline (omitted) is 1 year prior to entry. Robust standard errors are clustered at the census tract level. *** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$. High-tech is defined as fiber-to-the-end-user and terrestrial fixed wireless. Seven largest ISPs: AT&T, Frontier, Charter, Comcast, CenturyLink, Verizon, and Windstream. The cross-equation tests are based on seemingly unrelated regressions with robust standard error after centering the means of variables by census tract-ISP to estimate fixed effects

4.6. Discussion

This study examines how ownership structure affects incumbents' responses by comparing their responses to cooperative entry and investor-owned firm entry. I find that incumbents are more likely to upgrade their technology to high-tech in response to cooperative entry than investor-owned firm entry. Moreover, the effect is stronger in markets with a low level of competition, indicated by only one or two high-tech providers, than in markets with intense competition, indicated by more than two high-tech providers. The effect is also stronger for incumbents with the ability and incentives to respond aggressively to a competitive threat: the effect is stronger for the big providers that cover many geographic markets across the United States than for small local providers that cover a limited number of local markets. Furthermore, these results remain consistent even when cooperatives and investor-owned firms enter with high-tech. These findings suggest that the effects of entry by consumer-owned cooperatives on incumbents' responses are driven by their willingness to provide high-quality services and unique advantages in countervailing market power: strong consumer orientation that inspires greater consumer trust and loyalty and an unwillingness to have a mutual understanding with incumbents to minimize competition.

This paper makes several contributions to the literature. First, it adds to previous studies on cooperatives (Boone & Özcan, 2014, 2016; Chatterji et al., 2020; Ingram & Simons, 2000; Jeong et al., 2020; Schneiberg et al., 2008) by empirically examining the competitive effects of cooperatives and how their effects differ from those of investor-owned firms. This study also contributes to understanding the competitive dynamics among heterogenous organizational forms. Previous studies looking at these dynamics include Chatterji et al. (2020) on consumer-owned credit unions versus investor-owned banks; Casadesus-Masanell and Ghemawat (2006) on the distribution of profits and ownership (user-owned not-for-profit, open source (Linux) versus investor-owned for-profit firm [Microsoft]); and Wang and Shaver (2014, 2016) on different levels of state ownership (a central government-owned firm versus provincial government-owned firms). Heterogeneous competitive dynamics are expected given the numerous types of organizations, including different state-owned firms (Jia et al., 2019; Seamans, 2012; Wang & Shaver, 2014, 2016), public-private partnerships (Bruce et al., 2019; Kivleniece & Quelin, 2012; Quelin et al., 2019; Rangan et al., 2006), nonprofit firms (Chatain & Plaksenkova, 2019; Hwang & Powell, 2009), social enterprises (Dacin et al., 2011; Santos, 2012; Zahra et al., 2009), other hybrid forms (Battilana & Lee, 2014; Fosfuri et al., 2016; Luo & Kaul, 2019), and their (dis)advantages in providing different types of goods and services (Luo & Kaul, 2019). Therefore, more future studies looking at competition between diverse organizational types will extend understanding.

Second, by investigating incumbents' responses to cooperative entry and investor-owned firm entry, this study adds to the literature examining investor-owned incumbents' reactions to entry made by alternative organizational forms (e.g., Seamans, 2012). Furthermore, to my knowledge, this is the first paper to empirically study investor-owned incumbents' reactions to cooperative entry. While several papers have theoretically or qualitatively examined incumbents' responses to producer cooperative entry in the agriculture industry (Peterson & Anderson, 1996; Sexton, 1990; Sexton & Sexton, 1987), there has been a lack of empirical evidence on the effect and how it differs from that of investor-owned firm entry. The study also adds to the literature examining incumbents' responses to entry using means other than pricing (e.g., Lieberman, 1987; Smiley, 1988). It contributes more evidence in relation to technology upgrades as incumbents' response to entry (Seamans, 2012; Skiti, 2020b).

In addition to enriching the literature, this paper has important implications for public policy. Several scholars have criticized the traditionally favorable treatment afforded to cooperatives (e.g., exemption from the federal corporate income tax, access to federal funding, subsidies) as agricultural producer cooperatives have been seen to be inefficient compared to their investor-owned counterparts (Porter & Scully, 1987; Sexton, 1990). However, this paper empirically shows that cooperative entrants have stronger pro-competitive effects than investor-owned entrants, especially in markets with a limited number of competitors—effects that benefit consumers. Thus, this study provides evidence to justify such favorable policies toward cooperatives (Peterson & Anderson, 1996; Sexton, 1990; Sexton & Sexton, 1987). By empirically illustrating that cooperatives drive incumbent ISPs to improve their service quality in markets with limited competition, this study demonstrates that cooperatives play an important role in closing the digital divide.

Finally, it should be noted that this study suffers a few limitations. First, the findings are not easily generalizable to other geographic markets where broadband cooperatives are unlikely to enter, such as those with high population density, high income levels, and low social cohesion (Jeong et al., 2020). Second, while the FCC data are the most comprehensive measurement of Internet provision in the United States, the data does not perfectly reflect actual quality and coverage. The FCC counts a census block as "covered" when just one household in the block receives services. Third, while

CEM can substantially reduce endogeneity concerns in a similar vein to other matching techniques, it cannot control for unobservable factors affecting cooperatives' entry and incumbents' responses at the same time.

CHAPTER 5. CONCLUSION

5.1. Conclusion

This dissertation aims to further understand digital inequality and the role of cooperatives in relation to investor-owned firms. Chapter 2 describes that a substantial portion of the United States is stuck with outdated Internet technologies because mostly wealthy, urban communities have benefited from modern innovations (defined as high-tech) in Internet infrastructure, dominantly provided by investor-owned firms. The chapter also shows that the alternative ISPs, cooperatives, offer high-tech or high-quality Internet services to disadvantaged areas, such as low-income and rural communities. Such patterns of cooperatives contrast with investor-owned firms, motivating further investigation on the role of cooperatives in providing high-quality services in relation to investor-owned incumbents' service quality and how the entry of the new type of ISPs (cooperatives) affects investor-owned incumbents.

Chapter 3 extends the comparative governance approach and asks: Under what conditions are cooperatives better at providing infrastructure than investor-owned firms? This chapter theorizes that when the direct financial benefits from infrastructure provision are relatively low compared to costs, profit-maximizing investor-owned firms have little incentive to invest in high-quality or high-tech provisions. In this case, cooperatives that are owned and controlled by users are willing to provide high-quality or high-tech services since they internalize the externalities generated by high-quality infrastructure in addition to the direct financial benefits. I find that cooperatives are more likely to enter communities where existing investor-owned firms provide only low-quality services, especially in rural communities and communities with high-social cohesion.

Chapter 4 investigates investor-owned incumbents' competitive responses to cooperative entry compared to investor-owned firm entry. This chapter theorizes that the cooperatives' core principle—prioritizing member benefits over financial profits—will make a cooperative entrant a bigger threat than an investor-owned entrant who shares the mutual understanding with investor-owned incumbents— minimize competition and maximize profits. I find that incumbents are more likely to upgrade their technology to high-tech in response to cooperative entry than to investor-owned firm entry. Moreover, the effect is stronger in markets with a low level of competition, measured by only one or two high-tech providers, than in markets with intense competition, measured by more than two high-tech providers. The effect is stronger for the big providers that cover many geographic markets across the United States than for small local providers that cover a limited number of local markets.

5.2. Contribution to Literature

These findings contribute to the literature. Chapter 3 contributes to understanding firm strategy at the intersection of public and private interests (Cabral et al., 2019; Mahoney et al., 2009). Scholars who have addressed grand societal challenges have paid increasing attention to a comparative governance approach, an approach to systemically examining the most effective and efficient institutional arrangements in dealing with different types of societal issues (Kaul & Luo, 2018; Klein et al., 2019; Lazzarini, 2019; Luo & Kaul, 2019). By examining the benefits and costs of two distinct institutional arrangements—consumer cooperatives and investor-owned firms—in infrastructure provision, this study extends the comparative governance approach and sheds light on the role of cooperatives.

Chapter 4 contributes to the literature on competition among heterogeneous organizational forms (Casadesus-Masanell & Ghemawat, 2006; Chatterji et al., 2020; Wang & Shaver, 2014; 2016). By empirically investigating the competitive effects of cooperatives and comparing the effect with the ones of investor-owned firms, this study complements and extends several theoretical works suggesting that cooperatives serve as ways for consumers, suppliers, etc. to countervail market power (Asmussen et al., 2020; Galbraith, 1952; Sexton, 1990; Sexton & Sexton, 1987; Stiglitz, 2009).

5.3. Contribution to Public Policy

This dissertation also has important public policy implications. Providing and maintaining high-quality infrastructure has been a center of policy debates as some believe the central government should govern the infrastructure provision, while others believe it is best to leave things to private sector companies represented by investor-owned firms.

This dissertation highlights a third option—cooperatives—by demonstrating that cooperatives are an effective governance form in providing high-quality infrastructure in marginalized areas where investor-owned firms underserve. Cooperatives' entry has stronger pro-competitive effects compared to investor-owned entry, especially in markets lacking competition. This dissertation calls for more support for cooperatives in providing vital infrastructure in marginalized communities.

5.4. Discussion and Future Study

This dissertation suggests several directions for further investigation. First, while this dissertation sheds light on the role of Internet cooperatives in mitigating digital inequality, this is only a part of how cooperatives may benefit local communities. Case studies report that cooperatives significantly improved disadvantaged communities' growth, including education, healthcare, and business opportunities.

For example, after RS Fiber—a cooperative providing high-tech Internet service in rural Minnesota—started operation, the Minnesota College of Osteopathic Medicine decided to set up services in the rural community. The officials at the osteopathic college credit the high-tech Internet access brought by the local cooperative, saying, "Without the RS Fiber Cooperative, the city of Gaylord would not have even known about the opportunity to attract the proposed medical school," and "Higher educational institutions require gigabit internet access. Without this access, Gaylord would have had no chance of attracting the school to South Central Minnesota" (Carlson & Mitchell, 2016).

Although such anecdotal cases are insightful in understanding the community benefits generated by cooperatives, systematic evidence on the relationship between cooperatives' Internet service provision and community growth will be invaluable in deepening our understanding of the role of cooperatives. Examining the community benefits generated by Internet cooperatives can be challenging because, as my dissertation shows, cooperatives are likely to cover disadvantaged communities that also lack data for empirical analyses. Nevertheless, finding systematic evidence on the relationship between cooperatives' high-quality Internet provision and community growth will greatly benefit scholars, policymakers, and marginalized communities.

Second, cooperatives should be considered an effective grassroots solution to infrastructure provision and various problems in addition to digital inequality. More empirical evidence of various cooperatives' impact on meeting members' needs should be accumulated. While there are numerous existing cooperatives in many industries (e.g., electricity, water, mutual insurance, credit union, farm supply and marketing, healthcare, housing) to study their impact, new types of cooperatives have appeared as new industries emerged. For example, as the ride-hailing industry has grown, drivers have formed a driver-owned ride-hailing cooperative. By forming a driver-owned cooperative, all profits go back to drivers instead of paying a hefty commission of up to 40% on each trip to firms like Uber and Lyft (Toussaint, 2021). Moreover, during the pandemic, as more people delivered their foods, restaurants owners started a food delivery cooperative as an alternate solution to using firms like Grubhub, Door Dash, and Uber Eats that charge commissions up to 30% and provide low wage and almost no protection for delivery drivers (Girnus, 2021). A deeper and broader understanding of various cooperatives through empirical studies will help gain more support for cooperatives.

Third, while this dissertation focuses on cooperatives, business entities owned and democratically governed by their members, the same fundamental mechanisms of the coalition, groups of people bound by enforceable agreements serve their members and improve their position relative to others (Asmussen et al., 2020), can be found in different forms and context. The cooperatives I examine in this dissertation serve marginalized groups and countervail market power to minimize exploitation from lack of competition; however, this is not always the case because even powerful parties constantly seek to maintain or increase their power over other parties. For example, big technology firms form a coalition to shape favorable regulations. While not fully disclosed, Amazon is one of the tech firms that funded the Competitiveness Coalition, a coalition branded as a grassroots group, yet fights antitrust law (Birnbaum, 2022). Similarly, big oil firms fund American Petroleum Institute, a trade association representing oil and national gas firms, to resist new climate action from the U.S. government (McGreal, 2021). Such coalitions are not limited to influencing policymakers. The big six tech firms[50] agreed not to solicit each other's employees to reduce the bargaining power of valuable employees (Department of Justice, 2010). Given that forming a coalition is not a weapon only for weaker parties, investigating how both power holders and others react to each other's coalition and attempt to regain power will be interesting.

[50] Adobe Systems, Inc., Apple Inc., Google Inc., Intel Corp., Intuit Inc., and Pixar Animation Studios

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APPENDICES

Appendix 1. Mobile and Satellite Internet

Mobile Internet

Mobile Internet access utilizes cell towers to transmit data to mobile devices. Unlike fixed wireless, the mobile Internet connection is optimized for high volume demands with a low bandwidth, focusing on streaming the Internet or transferring voice data. Mobile Internet access is designed to be flexible, so it sacrifices speed and latency. Various technologies were developed to provide mobile Internet access, which are grouped into “generations” (i.e., 1G: AMPS, 2G: GSM, D-AMPS, IS-95, 3G: CDMA2000/EV-DO, WCDMA/HSPA+, 4G: LTE, LTE advanced, 5G: OFDM based air interface).[51] “Mobile broadband” is a marketing term, and broadband refers to fixed Internet connections that can provide high bandwidth. In the same vein, the FCC continues to conclude that current mobile services cannot substitute for fixed services such as DSL, cable, and fiber.[52] Therefore, in this dissertation, I do not include mobile Internet access and instead focus on fixed Internet connections.

Satellite Internet

Satellite Internet is wireless connection spread across satellite dishes located in space and on Earth. In general, satellite Internet is more expensive than other technologies. In addition, because satellites located far from Earth, high latency is a

[51] Qualcomm Technologies, lnc., 2016 (https://www.qualcomm.com/media/documents/files/making-5g-nr-a-reality.pdf)

[52] FCC, 2018 (https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report).

common and critical issue, which means the Internet traffic will need extra time to travel to outer space. The Internet signal is also subject to weather conditions; rain, snow, or other bad weather can create spottiness or outages. Therefore, current satellite technology is not comparable to high-speed fixed Internet technology due to its latency issue, lower speeds, and susceptibility to weather conditions.[53]

[53] FCC (https://www.fcc.gov/general/satellite)

Appendix 2. Alternative DVs

	DV: High tech coop								
	Panel A								
	Full sample	Subsample analyses using OLS fixed effects							
	OLS within	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M33	M34a	M34b	M35a	M35b	M36a	M36b	M37a	M37b
Investor-owned internet mean speed	-0.0029	-0.0025	-0.0023	-0.0009	-0.0037	-0.0018	-0.0038	-0.0019	-0.0035
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Test of differences across split samples[P-val]:		0.32[0.5732]		60.70[0.0000]		34.15[0.0000]		25.81[0.0000]	
Constant	-0.0338	0.0229	0.2358	0.0103	-0.2889	0.0400	-0.1669	-0.0478	-0.0902
	(0.4578)	(0.7037)	(0.0000)	(0.6957)	(0.0198)	(0.3665)	(0.0545)	(0.3305)	(0.2464)
Observations	285,320	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0151	0.0000002	0.0090	0.00002	0.0013	0.0122	0.0065	0.0081	0.0106
	Panel B								
	Full sample	Subsample analyses using OLS fixed effects							
	OLS within	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M38	M39a	M39b	M40a	M40b	M41a	M41b	M42a	M42b
% covered by high tech investor-owned internet	-0.0073	-0.0064	-0.0071	-0.0011	-0.0146	-0.0061	-0.0090	-0.0055	-0.0088
	(0.0000)	(0.0000)	(0.0000)	(0.0515)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Test of differences across split samples[P-val]:		0.17[0.6817]		39.09[0.0000]		3.23[0.0724]		4.31[0.0389]	
Constant	-0.0188	0.0116	0.2374	0.0152	-0.2835	0.0495	-0.1487	-0.0400	-0.0689
	(0.6792)	(0.8465)	(0.0000)	(0.5636)	(0.0222)	(0.2634)	(0.0863)	(0.4159)	(0.3744)
Observations	285,320	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0173	0.00002	0.0101	0.00004	0.0018	0.0169	0.0064	0.0114	0.0118

	DV: Coop internet mean speed								
	Panel C								
	Full sample	Subsample analyses using OLS fixed effects							
	OLS within	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M43	M44a	M44b	M45a	M45b	M46a	M46b	M47a	M47b
Investor-owned internet mean speed	-0.0155	-0.0107	-0.0132	-0.0032	-0.0209	-0.0064	-0.0238	-0.0089	-0.0200
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Test of differences across split samples[P-val]:		1.23[0.2674]		53.92[0.0000]		68.75[0.0000]		27.75[0.0000]	
Constant	-0.9073	0.0823	0.7291	-0.4297	-2.9268	0.2308	-2.5326	-0.7538	-1.5903
	(0.0007)	(0.7778)	(0.0201)	(0.0193)	(0.0001)	(0.3951)	(0.0000)	(0.0232)	(0.0002)
Observations	285,320	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0042	0.0016	0.0040	0.0002	0.0005	0.0019	0.0037	0.0003	0.0040
	Panel D								
	Full sample	Subsample analyses using OLS fixed effects							
	OLS within	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diversity	High immigration	Low immigration
	M48	M49a	M49b	M50a	M50b	M51a	M51b	M52a	M52b
% covered by high tech investor-owned internet	-0.0301	-0.0297	-0.0236	0.0059	-0.0723	-0.0114	-0.0523	-0.0019	-0.0536
	(0.0000)	(0.0000)	(0.0108)	(0.1392)	(0.0000)	(0.0613)	(0.0000)	(0.7659)	(0.0000)
Test of differences across split samples[P-val]:		0.30[0.5815]		27.23[0.0000]		13.89[0.0002]		22.24[0.0000]	
Constant	-0.8287	0.0366	0.7409	-0.4126	-2.8893	0.2591	-2.4180	-0.7318	-1.4707
	(0.0020)	(0.9002)	(0.0183)	(0.0246)	(0.0001)	(0.3404)	(0.0000)	(0.0279)	(0.0005)
Observations	285,320	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0042	0.0020	0.0038	0.000004	0.0006	0.0019	0.0037	0.00006	0.0044

Note. All control variables are included. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses.

Appendix 3. Analyses by Cooperative Type

Panel A					
	DV: Telecom coop	DV: Electric coop	DV: Other coop	DV: All legacy coop	DV: Internet coop
	M53	M54	M55	M56	M57
Investor-owned internet mean speed	-0.0013	-0.0009	0.0001	-0.0023	-0.0001
	(0.0000)	(0.0000)	(0.0060)	(0.0000)	(0.0017)
Constant	0.0513	-0.0834	0.0233	-0.0417	-0.0022
	(0.0396)	(0.0003)	(0.1448)	(0.2312)	(0.8016)
Observations	285,320	285,320	285,320	285,320	285,320
Number of censustractid	71,558	71,558	71,558	71,558	71,558
R-squared(overall)	0.00005	0.0034	0.0004	0.0129	0.0008

Panel B					
	DV: Telecom coop	DV: Electric coop	DV: Other coop	DV: All legacy coop	DV: Internet coop
	M58	M59	M60	M61	M62
% covered by high tech investor-owned internet	-0.0034	-0.0022	0.0002	-0.0054	-0.0003
	(0.0000)	(0.0000)	(0.4283)	(0.0000)	(0.1949)
Constant	0.0582	-0.0786	0.0226	-0.0300	-0.0017
	(0.0191)	(0.0006)	(0.1568)	(0.3886)	(0.8520)
Observations	285,320	285,320	285,320	285,320	285,320
Number of censustractid	71,558	71,558	71,558	71,558	71,558
R-squared(overall)	0.0002	0.0034	0.0004	0.0145	0.0008

Note. OLS fixed effects regression. All control variables are included. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses. Coops are categorized based on the service type that a coop is established to provide: telecommunication, electricity, Internet, or other (cable, energy, etc.). *All legacy coop* includes all coops except Internet coops.

Appendix 4. Supplementary Analyses on Download Speed

	DV: Coop	DV: High tech coop	DV: Coop	DV: High tech coop	DV: Coop							
	Full sample analyses				Subsample analyses using OLS fixed effects							
	OLS Within	OLS Within	2SLS 2nd stage	2SLS 2nd stage	High income	Low income	Urban	Rural	High ethnic diversity	Low ethnic diveristy	High immigration	Low immigration
	M63	M64	M65	M66	M67a	M67b	M68a	M68b	M69a	M69b	M70a	M70b
Investor-owned internet mean speed	-0.0023	-0.0028	-0.0583	-0.0587	-0.0020	-0.0019	-0.0008	-0.0029	-0.0013	-0.0031	-0.0015	-0.0029
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Test of differences across split samples[P-val]:					0.09[0.7642]		47.36[0.0000]		43.25[0.0000]		26.28[0.0000]	
Constant	-0.0335	-0.0347			0.0838	0.1547	0.0209	-0.2732	0.0160	-0.1331	-0.0513	-0.0689
	(0.3451)	(0.4459)			(0.0857)	(0.0000)	(0.4328)	(0.0031)	(0.6580)	(0.0443)	(0.2641)	(0.2052)
Observations	285,320	285,320	285,197	285,197	142,664	142,656	177,746	107,574	142,659	142,661	138,475	146,845
Number of censustractid	71,558	71,558	71,435	71,435	35,710	35,848	44,623	26,935	35,698	35,860	34,746	36,812
R-squared(overall)	0.0169	0.0155			0.0018	0.0181	0.000001	0.0003	0.0104	0.0090	0.0026	0.0147
Cragg-Donald Wald F statistic			397.74									
Kleibergen-Paap Wald rk F statistic			674.83									
Endogeneity test of endogenous regressors[P-val]			62.881[0.0000]	59.723[0.0000]								

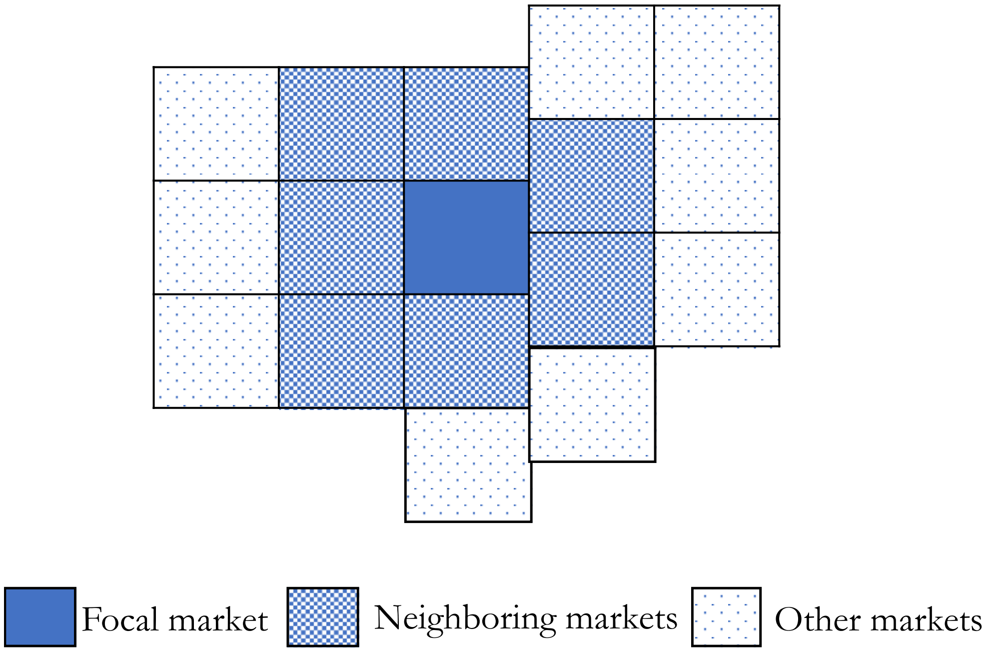
Note. All control variables are included. Year fixed effects and census tract fixed effects are included. Robust standard errors are clustered at the census tract level. *P*-values are shown in parentheses. Stock-Yogo weak ID test: critical value at 10% maximal IV size is 16.38.

Appendix 5. Alternative Specifications

	DV: Coop							
	Logit		Tobit		OLS Within	2SLS 2nd stage	OLS Within	2SLS 2nd stage
	M71	M72	M73	M74	M75	M76	M77	M78
Investor-owned internet mean speed	-0.5763		-0.0038		-0.0027	-0.0820		
	(0.0000)		(0.0000)		(0.0000)	(0.0000)		
% covered by high tech investor-owned internet		-3.3871		-0.0148			-0.0064	-0.6156
		(0.0000)		(0.0000)			(0.0000)	(0.0000)
log(Median HH income)	0.2094	0.7063	0.0157	0.0142	0.0191	0.0627	0.0177	0.0197
	(0.3005)	(0.0009)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ethnic diversity	-16.3073	-16.5110	-0.0848	-0.0847	-0.0002	0.0290	-0.0013	-0.0078
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.9705)	(0.0007)	(0.8113)	(0.4815)
Immigration	-10.7951	-15.2956	-0.0174	-0.0159	-0.0043	-0.0433	-0.0025	0.0436
	(0.0747)	(0.0204)	(0.5386)	(0.5743)	(0.8563)	(0.3080)	(0.9165)	(0.5064)
log(Population)	-0.0333	-0.3282	-0.0176	-0.0176	-0.0123	-0.0250	-0.0120	-0.0261
	(0.8009)	(0.0111)	(0.0000)	(0.0000)	(0.0015)	(0.0000)	(0.0019)	(0.0038)
Unemployment rate	-71.4360	-82.3079	-0.0639	-0.0718	0.0755	0.2836	0.0691	0.1385
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
% population above 65	4.9219	4.6399	0.0288	0.0244	0.0255	0.1688	0.0216	0.1081
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
% population with bachelor degree or higher	-24.5411	-22.6670	-0.1293	-0.1282	-0.0387	-0.0281	-0.0393	-0.0602
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0104)	(0.0000)	(0.0003)
% Native Americans	16.5947	21.0584	0.2547	0.2516	0.0856	0.1069	0.0838	-0.0139
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0542)	(0.0489)	(0.0593)	(0.8542)
Muni. gov.	1.9798	1.8413	0.0156	0.0155	0.0083	-0.0042	0.0087	0.0010
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0746)	(0.4798)	(0.0633)	(0.8993)
The number of for-profit providers	-0.2873	-0.1459	0.0004	0.0007	0.0020	0.0091	0.0020	0.0270
	(0.0000)	(0.0000)	(0.0090)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Areas with for-profit business services	1.4927	1.5820	0.0186	0.0196	0.0038	0.0514	0.0037	0.1457
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0187)	(0.0000)	(0.0277)	(0.0000)
Constant	-7.9287	-11.7626	0.1122	0.1298	-0.0988		-0.0837	
	(0.0006)	(0.0000)	(0.0000)	(0.0000)	(0.0093)		(0.0271)	
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Census tract fixed	No	No	No	No	Yes	Yes	Yes	Yes
Observations	285,320	285,320	285,320	285,320	267,067	266,947	267,067	266,947
Number of censustractid	71,558	71,558	71,558	71,558	66,989	66,869	66,989	66,869
R-squared(overall)					0.0091		0.0086	
Cragg-Donald Wald F statistic						246.95		78.25
Kleibergen-Paap Wald rk F statistic						325.33		75.92
Endogeneity test of endogenous regressors[P-val]						62.791[0.0000]		65.710[0.0000]

Note. All models include census tract random effects. Standard errors are clustered at the census tract level for logit models. Models M75 to M78 exclude the census tracts where a cooperative ISP was present at the start of the sample period. *P*-values are shown in parentheses. Stock-Yogo weak ID test critical value at 10% maximal IV size is 16.38.

Appendix 6. Assessing Neighboring Markets



Note. ArcGIS Pro Polygon Neighbor analyzes first-order contiguity based on area of overlaps (overlapping neighbors), the length of coincident edges (edge neighbors), and the number of times boundaries cross or touch at a point (node neighbors).

Appendix 7a. Distribution of the Total Number of ISPs Providing High-Tech Internet Before Entry

	#	Not treated	Treated	Total	%
# of ISPs	0	912	83	995	21.69
providing high-	1	1,165	229	1,394	30.39
tech internet	2	733	319	1052	22.93
before entry:	>2	910	236	1146	24.98
	Total	3,720	867	4,587	100

Note. Terrestrial wireless and fiber-to-the-end-user are classified as high-tech.

Appendix 7b. Distribution of the Total Number of ISPs Providing High-Tech (Fiber-to-End-User Internet) Before Entry

	#	Not treated	Treated	Total	%
# of ISPs	0	1,784	318	2,102	45.83
providing high-	1	1,310	327	1,637	35.69
tech internet	2	516	168	684	14.91
before entry:	>2	110	54	164	3.58
	Total	3,720	867	4,587	100

Note. Only fiber-to-the-end-user is classified as high-tech.