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UTILITY POLE POLICY:

A Cost-Effective Prescription for Achieving Full Broadband Access in North Carolina

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A Cost-Effective Prescription for Achieving Full Broadband Access in North Carolina[1]

By: Edward J. Lopez[2] and Patricia D. Kravtin[3] August 2021

HIGHLIGHTS AND TAKEAWAYS

- State and federal grant funds have recently been awarded to help defray the total cost of broadband expansion in North Carolina, with more funding on the way. We estimate that full realization of the federal portion alone would create an estimated $3.5 billion in new economic gains to North Carolina businesses and households, calculated as aggregate additional *willingness-to-pay*. This estimate demonstrates the potential magnitude of the public's return on its broadband investment, namely the productive, commercial, educational, health, civic and other social benefits that stand to be realized by achieving full broadband expansion.
- The public's return on its broadband investment requires efficient, unimpeded attachment of broadband wires to existing utility pole networks. However, current policies allow municipal and cooperative ("Muni and Coop") electric pole owners to exercise significant *market power* over pole attachment rates and terms, including onerous timetables and permitting fees, various pre- and post-construction requirements, and full pole replacement as part of the "make-ready" process that occurs on the front end of pole attachment. These inefficient charges and practices raise broadband deployment costs, causing delayed or foregone expansion to consumers.
- We calculate each month of delayed broadband expansion would cost a statewide estimated $14 to $16 million of *deadweight loss*, or simply foregone economic gain. Closing the digital divide has risen to the forefront because too many in North Carolina, especially in rural areas, have lacked connectivity for too long. Further delay adds up to $186 million per year of economic gains not realized because of delayed broadband expansion. These estimates are conservative because they include only federal expansion plans, do not fully reflect the value of the higher network speeds and lower latency prioritized in the federal grant programs, and do not account for increased broadband demand since the pandemic, especially in the state's expansive rural areas.

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HIGHLIGHTS AND TAKEAWAYS (CONTINUED)

- Economic theory classifies utility poles as a textbook example of a *natural monopoly,* meaning a single network of poles can supply access to all locations in an area at a lower cost to society than two or more sets of poles can. Utility poles are also akin to a *public good* because once a network of poles is constructed, pole attachments then are to a degree *non-rival in use,* meaning new attachments can be accommodated without causing the exclusion of others. Policies that promote efficient pole attachments also promote full broadband expansion, whereas unchecked exercise of market power by Muni and Coop pole owners impedes achievement of this important public interest goal.
- The lack of consistent policies governing the rates, terms, and conditions surrounding make-ready charges has become a growing public interest problem as the need for expanding broadband services into unserved rural areas has become a critical necessity, and pole owners have increased anti-competitive incentive to impede entry by third-party providers as their own interest in providing broadband is becoming the norm.
- The public's return on current broadband investment is vulnerable to the leverage pole owners enjoy over broadband providers, intensified by the former's information advantage. The amounts of pre-assigned grant funds are publicly disclosed, by provider name and location. That a Muni or Coop pole owner in a rural area is aware of these pre-commitments, and can use it as leverage to impede broadband expansion in their area, is known in economics as a *hold up problem*, i.e., the power to impede others' ongoing investment plans. A hold up problem is classified in economics terms as an example of the inefficient concentration of market power that harms the public interest.
- Significant concentration of market power over an essential input in an otherwise competitive ecosystem is always detrimental to the public interest. The efficient policy prescription that serves the public interest is to level the playing field. Too many Carolinians have gone without broadband access for too long. Given the high value stakes involved, and taxpayer-funded grant money on the line, policy makers should act now to ensure full broadband access is achieved in the most timely, cost-effective manner.
- In particular, policymakers should take steps to put into place an efficient and equitable cost sharing arrangement between broadband attachers and pole owners for the costs of pole replacement to keep costs to new attachers closer to efficient, competitive, yet compensatory to pole owners, levels. Such arrangements would take into account the age and net book value of the replaced poles, so as preclude, as a precondition of attachment, broadband providers being made to bear the full monetary burden of replacing aging poles the utility would have to replace at its own cost in the near future in the absence of the new attachment.

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1. Introduction and Overview

Before a business or household can acquire access to high-quality broadband service, broadband service providers must run a connection (e.g., fiber/coaxial cable transmission facilities) from their network to these locations. Often, the only practical and economically feasible means to do so is to attach their wires to the existing network of utility poles. As a result, utility pole owners control a bottleneck input, standing between third-party broadband providers and North Carolina's currently unserved households and businesses. This paper addresses: (1) the public interest problem that has arisen as pole owners have exercised publicly harmful market power over the rates, terms and conditions of pole access make-ready, raising broadband costs and causing delayed and foregone physical and economic expansion of broadband into unserved rural areas of the state; and (2) the public policies needed at this time to remedy this harmful public interest problem.

Historically, under the federal Pole Attachment Act of 1978, Muni and Coop pole owners have been exempt from federal regulation of rates, terms and conditions. Largely exempt from regulation, evidence suggests Muni and Coop pole owners engage in the charging of higher recurring pole attachment rental rates as compared to their Investor-Owned counterparts (Connolly 2020, 2019). Even where subject to regulation at the state level for the recurring rates associated with attachment to the poles (i.e. annual pole rent), as here in North Carolina, Muni and Coop pole owners have been granted largely unfettered discretion in setting the rates, terms, and conditions applicable to the upfront, non-recurring set of charges known as "make-ready" that owners are allowed to charge in addition to recurring rental rates.

Significant concentration of market power over an essential facility (namely, pole attachments) in an otherwise competitive ecosystem always harms the public interest. In this case, households and businesses who want broadband access are better off when broadband service providers can attach in a timely, efficient, predictable and cost-effective manner to existing pole networks rather than being subject to the whims of pole owners with discretionary market power and economic incentive to delay or even effectively prohibit another party's broadband expansion plans.

The digital divide in broadband access, especially its very harmful impacts on households and businesses in unserved rural areas, has now risen to the policy forefront. North Carolina's GREAT act (Growing Rural Economies with Access to Technology) promotes broadband expansion in the state through a grant program. The GREAT act appropriates funds from the state to support broadband expansion and allows providers to compete for that money through a grant application program. Federal support is also available through the FCC's Rural Digital Opportunity Fund (RDOF), the recently announced U.S. Department of Commerce's National Telecommunications and Information Administration (NTIA) Broadband Infrastructure Program, as well as provisions within the American Rescue Plan Act (ARPA) and other federal stimulus programs. Under ARPA, for example, North Carolina was allocated $5.4 billion for total infrastructure spending, and the current session of the General Assembly is considering a $700 million broadband infrastructure package. North Carolina's counties and rural incorporated areas also receive substantial ARPA infrastructure funds, some portion of which is expected to be directed at broadband expansion. The overarching goal of these programs is to expand access to high speed fixed broadband connections to currently unconnected rural homes and small businesses (FCC 2020).

The framework applied to the RDOF auctions directly tied support to the number of locations served. Completed in 2020, the reports of those auctions include the dollar amounts and corresponding number of locations assigned. In North Carolina, under the RDOF program alone, third-party providers have committed to expanding high-quality broadband access to as many as 155,137 currently unserved homes and small businesses, the vast majority located in the state's rural areas. By directly tying support to locations, the RDOF framework dovetails with an existing body of economics research that quantifies the household value of broadband access. This paper develops a methodology that we use to estimate the full expansion of broadband to all assigned RDOF locations in North Carolina would generate $3.5 billion of economic gains, measured as additional *willingness-to-pay*. This estimate helps to grasp the potential magnitude of the public's return on its broadband investment that would make possible the full range of productive, commercial, educational, health, civic, and other social benefits that stand to be realized by full broadband expansion. These estimates will be considerably higher when calculating the impact of additional local, state, and federal funding from the GREAT Act, NTIA, ARPA and similar programs.

However, our estimates imply that if pole owners continue to exercise publicly harmful market power, this jeopardizes the return on the public's investment in broadband measured as foregone economic gains to unserved households and businesses. For each month of delayed expansion due to pole owner market power, we estimate Carolinians forfeit an estimated $16 million, or $186 million on an annualized basis. Our estimates of $3.5 billion gain, as well as $186 million delay cost per year, are conservative in magnitude, in part because they include only RDOF funds, and for additional reasons as we discuss below.[4] The adoption of utility pole policies necessary to achieve cost efficient and full broadband expansion cannot come soon enough. Each day without such policy changes has a substantial negative impact on communities in North Carolina lacking adequate broadband access.

4. There is every reason to expect that these programs will generate more economic gain, i.e. more *willingness to pay* as measured in this paper. However, the model in this paper is designed to measure gains at the level of individual households becoming connected. The model only indirectly measures the gains of additional expenditures. Since GREAT act, NTIA, ARPA and other ongoing public investments have not reported locations, our methodology does not lend itself to generate the same estimates of economic gain as it can for RDOF locations. This is one reason why our estimated gain of $3.5 billion, and the estimated $186 million of annual delay cost, are both conservative in magnitude.

2. Pole Attachments: A Critical Input to Achieving Full Broadband Expansion into Unserved, Rural Areas of North Carolina

In order to economically achieve full broadband expansion, broadband service providers must attach to existing utility poles. In this sense, pole owners stand between third-party broadband providers and end-user households and businesses. In economics terms, pole attachments are *essential facilities* known as *intermediate goods*, i.e., inputs that are vital to the production of the final good, which in this case is connecting rural Carolinians to high-quality broadband service. Economic theory also classifies utility poles as a textbook example of a *natural monopoly*. According to the most recent edition of a top-selling economics textbook: *"A natural monopoly is said to exist when a single firm can supply the entire market at a lower cost than two or more firms"* (Cowen and Tabarrok 2021, p.263). Therefore, not only are pole attachments a critical input to achieve full broadband expansion into North Carolina's unserved, rural areas, pole owners enjoy a natural monopoly over the supply of this vital intermediate good.

For third-party providers seeking to achieve full broadband expansion, no real cost-effective alternative exists other than to attach onto existing networks of utility poles. The notion that broadband providers have practical alternatives, e.g., building underground, is unrealistic given the prohibitively higher costs as compared to aerial installations and the host of other practical, environmental, and topographical barriers associated with the construction of underground facilities.[5] To build additional pole networks separate from existing ones would be a waste of social resources and aesthetically undesirable, and may be prohibited under many areas' zoning rules, environmental regulations and other laws and ordinances. Because pole attachment is a critical input, broadband expansion is delayed or foregone when pole owners can exercise their market power by charging excessive and economically unfeasible pole attachment or replacement fees.

Furthermore, once a network of poles is constructed, pole attachments then are *non-rival in use*, up to a point of full capacity rare in the case of poles.[6] This means that third-party providers can attach to existing poles, thus connecting more Carolina households and businesses, without interfering with other parties' ability to also attach, and without raising pole owners' marginal costs or ability to earn a fair return on invested capital. This is the reason economics classifies utility poles akin to a *public good*, because they are a natural monopoly that is also non-rival in use. Due to these underlying characteristics of poles, the public interest is best served by policies that strongly promote and facilitate the attachment to utility poles by third-party broadband providers, especially as those attachments are necessary inputs to achieving cost efficient and full broadband expansion – a public policy goal more urgent than ever with the intensified digital divide over the past year.

[5] For example, certain topographical features such as rock and wetlands and other environmental impact concerns can render underground installations practically infeasible. Similarly, underground installations that involve the costly transactional and time-consuming process of acquiring permission and necessary easements to occupy private property from individual property owners to the extent the underground construction does not follow existing utility easements make it a practically infeasible option. In addition, underground construction requiring road cuts can disrupt traffic and commerce, and typically involves obtaining a host of local governmental permits, which can add materially to the costs, complexity, and timing of the project.

[6] Poles are manufactured in 5-foot increments, meaning the typical third party attacher is occupying otherwise surplus space on the pole. Moreover, additional space on poles is readily accessed through regular utility make-ready work. See In the Matter of Florida Cable Television Ass'n et al v. Gulf Power Co., Initial Decision of Chief Administrative Law Judge Richard Sippel, EB Docket No. -4-383, para. 25 (rel. January 31, 2007) ("where capacity is available through rearrangement or expansion of a pole's height, its capacity cannot be full.")

Especially since the onset of the COVID-19 pandemic, broadband access has become even more vital to ensuring equality and inclusivity of opportunity and information. As remote learning and work-from-home became the norm in 2020, "America witnessed its biggest ever surge in internet traffic with spikes of 60% in some markets" (NCTA 2021). The pandemic's surge in broadband demand persisted throughout 2020, especially with upload demand that rose by 60% from March to December, as students and workers nearly tripled their use of videoconferencing (BITG 2020). In this sense, the nation's internet infrastructure performed well under sudden and intense conditions. However, those without broadband access could not participate, or were subject to the hardships of driving long distances to fast-food and public library parking lots to obtain connectivity. Unserved households and businesses fell even further behind in terms of being connected to the social, civic, educational, health, entertainment, and other benefits of access to high-quality broadband internet. Given the further intensification of the digital divide in 2020, the efficacy of public investment funds and utility pole policies to achieve full broadband expansion are more vital than ever.

3. Pole Owners Enjoy Publicly Harmful Market Power over the Essential Pole Input when Granted Unregulated Privileges in an Otherwise Competitive Ecosystem

Historically, under the federal Pole Attachment Act of 1978, Muni and Coop utilities have been exempt from federal pole rate regulation. In some states, including North Carolina, Muni and Coop pole owners are subject to rate regulation with respect to recurring annual rental rates, but have been granted largely unfettered discretion in setting the rates, terms, and conditions applicable to the upfront, non-recurring set of charges pole owners are allowed to impose, which are also known as "make-ready" charges. These later charges, by imposing both excessive costs and delays, pose particular challenges to broadband deployment.

Excessive costs imposed by one utility depletes resources available to the broadband provider to apply in that locality, but also elsewhere, creating a cascading set of social costs and *negative* externalities associated with delayed or impeded broadband deployment in unserved areas of the state.[7] These flow-through effects, while present previously, have grown in significance given the urgency and unprecedented scale and scope of current broadband initiatives. The barriers associated with high make-ready charges and delay related costs did not so much come into play in the past. This is because the absence of governmental subsidies greatly limited deployments in unserved areas given the particular challenges of serving rural populations. Today, the scale of expansion plans now anticipated under existing and future state and federal funding programs as identified above are far greater in scale and scope than before. The magnitude of the utility pole problem has grown in lockstep. This is one reason why our estimates of public interest value created by full broadband access are so substantial.

[7] See FCC 18-133, WT Docket No. 17-79, WT Docket No. 17-84) September 27, 2018, Declaratory Ruling and Third Report and Order, especially at p.51 (noting "the manner in which capital budgets are fixed ex ante"), and pp.60-69 (explaining the requirement that fees be set to recover objectively reasonable costs as applying to all types of fees that drain limited capital resources that otherwise could be used for deployment).

Disproportionately high make-ready charges borne entirely by the broadband provider that do not take into account the offsetting betterment and savings to the pole owner[8] associated with pole replacements—an activity that would be occurring in the normal course of utility operations in the absence of the new broadband attachment—result in rates for the vital pole attachment input well in excess of an efficient, competitive level. By this we mean the rates that would be charged the broadband provider in a competitive market for pole attachments, if one existed, rather than under existing natural monopoly market conditions.

As detailed further below, imposing disproportionately high make-ready charges on third party attachers leads to inefficient, and distorted investment decisions for both third party providers and pole owners. These adverse incentives generate outcomes that fail to serve the public interest of North Carolinians: broadband providers are not able to build out as far or as quickly to households in the target unserved areas, and as economic theory predicts investment could be redirected elsewhere in the state (or toward states where more favorable pole policies with respect to pole replacement exist). In addition to third party providers facing disincentives for future broadband investment, absent updated pole policies, pole owners will lack incentive to provide the level and quality of broadband they might otherwise have, if subject to unimpeded competitive pressures.

There are a number of key differences in operating conditions for the pole owner vis-à-vis the broadband provider in the end user markets they serve. These reinforce asymmetric bargaining power, i.e., leverage of the utility over the broadband provider, that exists at the front-end of any planned broadband expansion and applies regardless of the broadband provider's size or market reach. Coops and Munis, face relatively little regulation of their electric distribution business as compared to their Investor-Owned counterparts. Yet, these utilities are effectively guaranteed a reasonable return on their investment and the full recovery of expenses they incur to provide electricity service through cost-free access to member capital in the case of Coops, or general tax and bond authority in the case of Munis.

Broadband providers enjoy no comparable guarantees, and operate in a market environment where they compete for customers and investment funding with other providers (increasingly with the pole owners themselves) using different platforms and technologies (i.e., wireline, wireless, and satellite). As illuminated above, cable operators and other providers of communications and broadband services were never expected to build parallel pole networks for the delivery of their services. Rather, public policies have historically relied on the use of economic regulation to ensure just and reasonable access to these ubiquitous utility-owned pole facilities by cable operators and other communications companies to provide services to users. This regulated natural monopoly approach to utility poles does not apply to the dynamic, increasingly convergent market for communications and broadband services.

[8] See Kravtin (2020, pp. 13-14, 37). (Betterment to the utility associated with a replacement pole include "operational benefits of the new pole (e.g., additional height, strength and resiliency that can enhance the productive capacity of the plant to meet service quality and other regulatory mandates; strategic benefits including the ability to offer additional service offerings and enhancements (e.g., smart grid applications) as well as broadband in competition with the attacher; revenue-enhancing benefits, including enhanced rental opportunities from the increased capacity on the new pole, capital cost savings associated with future planned plant upgrades and cyclical replacement programs; operational cost savings in the form of lower maintenance and operating expenses inherent to the features of the new, upgraded/higher class replacement pole, or as a result of the earlier time shift of the removal and installation of the new pole.")

Utilities often cite to the total revenues or profitability of the broadband providers as support for their ability to pay high fees for access to the pole input. This argument, however, runs counter to the public interest by ignoring the end-user benefits created by third-party access to the essential pole facility. Economic theory is very clear about what drives the public interest in these kinds of situations. The public interest is not harmed because third-party providers must pay high rates per se (in economics, a higher price paid in a transaction is also a higher price received in that same transaction, so the price itself is a net wash). Rather, the public interest is harmed when household and business broadband access is further delayed, or not served at all, because of the fact that pole owners charge economically unreasonable, high rates and impose unreasonable terms and conditions for accessing the pole.

Exacerbating the problem is that pole owners' pecuniary self-interest to impose unreasonable terms and conditions and charge high rates and cause delay has been greatly magnified in recent years by their own plans to compete in the broadband market either directly or through an affiliate or partner. When the pole owner itself, or through an affiliate entity, is a provider of broadband, or has imminent plans to enter the market, the pole owner has even greater incentive to engage in behaviors and practices that favor its own or affiliates' interests by creating or further solidifying inefficient barriers to entry for third party broadband providers.

As the digital divide has risen to the policy forefront, substantial taxpayer funds have been pre-assigned in publicly disclosed amounts and locations to support the cost of achieving full broadband expansion, and utility poles as essential facilities are a necessary input to generating the intended return on public investment. Unserved, rural locations in North Carolina have been unconnected for too long, and the vital support by policymakers of these federal and state taxpayer-funded programs by adopting policies to fix the pole problem is the right policy for removing barriers to infrastructure investment in the state.

4. How Pole Owners' Market Power Harms the Public Interest by Raising Broadband Costs, Causing Further Delays to North Carolina Households and Businesses Achieving Full Broadband Access

Munis and Coops have adopted a number of practices, with regard to access to their poles, especially those in connection with make-ready requiring pole replacements, that serve pole owners' pecuniary interests to the detriment of the greater public interest, as our estimates below of foregone public interest value calculate (Kravtin 2020, p.9-10). For example, in one major broadband construction project that to date has included over five thousand miles of new rural plant, a major broadband service provider faced situations in which the pole owner was requiring as many as one out of every twelve of its poles be replaced at the broadband provider's full expense as condition of hosting broadband providers attachment. This requirement was notwithstanding the fact that the average pole to be replaced was already several decades into its service life and hence close to the date it would be replaced soon by the utility as part of its own normal routine operations (NCTA 2020, p.6). These practices are quintessential examples of hold up power used opportunistically to extract rents and disrupt others' pre-committed and ongoing investment plans. The result being, that in a major broadband expansion project to over 57,000 rural homes and small businesses, pole replacement costs *alone* accounted for approximately *25 percent of the total cost* of construction (including applications, surveys, permitting, labor, and material).

This broadband provider's experience is not unique. Based on other reported experiences by broadband providers, unreasonable and costly pole replacement demands by pole owners is becoming increasingly common in connection with planned expansion in unserved rural areas (NCTA 2021, p.6-7) with detrimental impacts on the ability of broadband providers to invest in a timely rollout of new services into the areas. This is a growing policy problem as these impacts further compound the already relatively high costs of building out in less densely populated rural areas where the need for high quality broadband is most pressing and that could benefit the most from increased private investment.

Because make ready work comes into play at the very front-end of a prospective broadband expansion, unreasonable rates, terms and conditions for make-ready create especially formidable and unpredictable entry barriers and deployment delay. Expansions into unserved rural areas face a number of initial economic hurdles; more costly and remote, harder to reach locations with lower population densities require broadband providers to attach to a larger number of poles to reach any given subscriber. Some unserved areas are estimated to require as high as 10 or more poles per subscriber. Given the inherently challenging business case to begin with, unfavorable make-ready rates, terms, and conditions are more likely to tip the scale from a go to no-go decision for a given location, or significantly impede the geographic coverage of a particular expansion project.

In addition, because make-ready charges apply at the front end and are imposed at the unpredictable, and unfettered discretion of the pole owner, any pricing distortions in these charges enter directly into the broadband providers' capital expenditure decision making process, not just in the specific locality of the make-ready work, but within the larger scope of the provider's build out plans throughout utility service areas and throughout the state. The economics of capital budgets are such that they are fixed well in advance subject to the disciplines of established budget forecast planning and financing procurement processes.

Just as excessive recurring rates raise the transactional costs of entry, so too do inefficiencies and delays in the make-ready process pertaining to a host of pre-construction and construction activities and timelines that raise transaction costs of entry. Such delays can be especially onerous in connection with the replacement of poles. In some respects, these "indirect" time-related transactional costs can be even more harmful to the provider's bottom line because of their direct impact on getting high quality product to market and meeting initial customer expectations and investor and/or grant requirements. These indirect cost factors also result in less broadband deployment, hurting local economies that do not get it or that get it delayed into the future, given linkages of broadband to lost productivity, less economic opportunity, less educational opportunities, and less access to medical care and other civic services.

While pole attachment rates are one of many interrelated factors affecting broadband deployment and adoption rates, national adoption and deployment data provides supporting evidence that the North Carolina approach of adopting more effective pole rate regulation of Muni and Coop pole owning utilities better promotes the public interest.[9] Just as North Carolina leads the nation in public interest driven pole policy with respect to recurring rates

[9] Take as case in point the state of Arkansas, widely recognized as adopting pole rate policies among the least favorable from a broadband deployment/competition-promoting perspective as compared with the federal pole rate formula applied in North Carolina. In addition to ranking near the bottom (47th) of statewide reported fixed broadband adoption rates (49%) as compared with North Carolina which ranks 17th with a 71% statewide adoption rate, Arkansas, also ranked near the very bottom nationwide with respect to the percent of the rural population with access to fixed broadband facilities at 25/3 Mbps. Specifically, Arkansas ranked 45th nationwide, with 34% of the population without access, as compared with the comparable statistic for North Carolina of 13% (at 20th rank). *See FCC Fourteenth Broadband Deployment Report,* rel. January 19, 2021, FCC 21-18, APPENDIX A, Deployment (Millions) of Fixed Terrestrial 25/3 Mbps; Mobile 4G LTE with a Minimum Advertised Speed of 5/1 Mbps; and Mobile 4G LTE with a Median Speed of 10/3 Mbps by State, District of Columbia and U.S. Territory (December 31, 2019).

charged by Muni and Coop utilities,[10] this paper illustrates the potential value to consumers realizable if the state expands its embrace of public interest serving policies with respect to non-recurring make-ready pole costs.

5. Economics of Pole Attachment: Pole Owners' Market Power Derives from Barriers to Entry and Hold Up Problems That Harm the Public Interest as Measured by Foregone Consumer Value

The economic propositions set forth in this paper highlight a classic fork-in-the-road scenario, as illustrated in Figure 1 below. Along one fork, broadband expansion is fully achieved on the planned timeline, and Carolinians who are currently unserved will gain access quicker. Along the other path, pole owners exercise a unique form of market power—creating what is known in economics as *the hold up problem*—which causes currently unserved Carolinians to wait even longer. This exercise of hold up power by the pole owners harms the public interest, which economics measures as *deadweight loss*. This measure of public harm in turn implies a straightforward policy prescription: the state of North Carolina should curtail the ability of Muni and Coop pole owners' ability to exercise market power that holds up full broadband access.

Figure 1: The Fork in the Road to Full Broadband Expansion: Delay Path vs. Expansion Path

Delay Path	Pole owners are peremitted to continue exercising substantial *market power* in pole attachments.	This market power is a supply-side market failure known in economics as *The Hold Up Problem*	Subject to *Hold Up Problems*, pole attachments become economically unfeasible	Pole attachments are delayed/prevented, blocking public investments to achieve broadband expansion	For each year of delay, Carolina households and businesses lose nearly $200 million or more in foreign economic gains.
	→	→	→	→	→
Expansion Path	Pole owners do not exercise market power in pole attachments	This avoids the supply-side market failure known as *The Hold Up Problem*	By neutralizing *The Hold Up Problem*, pole attachments are economically feasible	Pole attachments are timely, public investments intended to achieve full broadband expansion are made	Carolina households and businesses receive broadband access and gain an estimated $3.5 billion or more.

[10] See Rutherford EMC v. Time Warner Entertainment—Advance/Newhouse, No. 13-CVS-231, 2014 WL 2159382 (N.C. Super. Ct. May 22, 2014), aff'd, 771 S.E.2d 768 (N.C. Ct. App. 2015); Time Warner Cable Se. LLC v. Carteret-Craven EMC, Order Resolving Pole Attachment Complaint Pursuant to G.S. 62-350, Docket No. EC-55, Sub 70, at 60 (NCUC Jan. 9, 2018); Time Warner Cable Se. LLC v. Jones-Onslow EMC, Order Resolving Pole Attachment Complaint Pursuant to G.S. 62-350, Docket No. EC-43, Sub 88, at 61 (NCUC Jan. 9, 2018); Time Warner Cable se. LLC v. Surry-Yadkin EMC, Order Resolving Pole Attachment Complaint Pursuant to G.S. 62-350, Docket No. EC-49, Sub 55, at 58-60 (NCUC Jan. 9, 2018); Union EMC Corp. v. Time Warner Cable Se. LLC, Order Resolving Pole Attachment Complaint Pursuant to G.S. 62-350, Docket No. EC-39, Sub 44, at 59-61 (NCUC Jan. 9, 2018); Blue Ridge EMC. v. Charter Communications Properties, LLC, Order Resolving Pole Attachment Complaint Pursuant to G.S. 62-350, Docket No. EC-23, Sub 50, at 73-74 (NCUC Oct. 17, 2018).

Notice that the hold up problem occurs at the point of an intermediate good, namely pole attachments. Yet, as with all market failures that occur on the supply sides of otherwise competitive ecosystems, pole owner hold up problems ultimately result in harm to end-user consumers. The inefficient pole owner practices regarding the rates, terms, and conditions for access to poles have a decidedly negative impact on consumers in unserved areas in multiple ways: getting fewer households served with broadband, delays in service, higher costs of service, and lost economic productivity, development and growth associated with broadband expansion.

5.1 The Underlying Source of Market Power: Barriers to Competition and the Hold Up Problem

The underlying source of pole owners' market power is a combination of barriers to competition and the hold up problem. Earlier in this paper, we explain why a single network of poles can supply access to all locations in an area at a lower cost than two or more pole networks can, and that once a network of poles is constructed, additional pole attachments are to a degree non-rival in use. These represent classic barriers to entry (Appendix A elaborates).

As for pole owners' unique possession of hold up power, this originates from the sequential nature of the public investments as rolled out under current expansion plans. The hold up problem is the power to impede others' ongoing investments by controlling an input that the return on those investments relies on. As Appendix A details, hold up problems arise in scenarios where one party, say the public, makes an initial investment that is called "relationship-specific" because its return depends on another party, say Muni and Coop pole owners, subsequently contracting for a necessary input.

RDOF and the other federal and state programs discussed in Section 1 represent taxpayers exercising reliance on pole owners to achieve full broadband expansion. If the allocation of those funds is to generate a return on the public's investment, the next step in the sequence toward full broadband expansion is the necessary, timely provisioning of the intermediate good, namely the pole attachment. However, all parties, including the pole owners, know the detailed information disclosed in RDOF awards and assignments.

Given that pole owners control a necessary bottleneck input, combined with the fact that publicly available information discloses the amounts and locations of pre-assigned public funds, this creates the ideal scenario for opportunistic behavior as described by the hold up problem. Appendix A of this paper provides a more in-depth explanation. The important implication is to recognize that pole owners uniquely possess hold up power in this ecosystem, and when exercised it is the source of delayed broadband expansion, and this harms the public interest as measured by foregone economic gains.

5.2 Empirical Methodology and Calculations

Economics postulates that a household whose internet access improves from a poor connection, such as mobile connectivity at slow speeds, to a high-quality fixed terrestrial wireline connection at high speeds, has some willingness to pay (WTP) for that improved connection. The household's WTP is how economics measures the dollar-equivalent value to that household of being connected to the social, civic, educational, health, entertainment, and other benefits provided by access to high-quality broadband internet. The most recent edition of a top-selling economics textbook defines WTP as *"the maximum price a consumer will pay for a good; also called the reservation price"* (Mateer & Coppock 2020, p.153).

Federal expansion plans under RDOF are structured to incentivize broadband deployment at high speeds. For example, in the large majority (85%) of RDOF locations, winning bidders have made commitments to deploy service at gigabit-speeds (USAC 2021). As explained in this section and Appendix B below, our estimates of WTP reported in Table 1 extend up to these high speeds. For example, suppose an individual household or business in North Carolina currently has only Mobile 5/1 access, but full broadband expansion would improve this household to Fixed Terrestrial 1000/100 access or higher. The household's WTP for this improvement measures the gross economic gains to this household of achieving full broadband expansion. We can then sum up for all North Carolina households to calculate the statewide economic gains.

As a complementary measure of economic gains, *consumer surplus* (CS) is a standard textbook method that is based on WTP. As Appendix B below details, CS is calculated by subtracting the price paid from the household's WTP. Typically, the price paid is understood in economics as a transfer from the consumer to the producer, some of which is used to defray costs of production, and the remainder of which is counted as the counterpart to CS, namely producer surplus. Therefore, WTP encompasses the net economic gains to consumers, the costs of production, and the net economic gains to producers. Both WTP and CS measures are standard tools used in economic policy analysis that provide complementary measures that can be used to estimate the dollar-equivalent value of closing the digital divide.

To estimate the household's WTP, a straightforward approach would be to simply ask them: "how much are you willing to pay to improve the speed of your access from mobile 5/1 Mbps to fixed 1000/100 Mbps?" A major limitation of this approach is that survey responses to unconstrained questions rarely reflect what responders would do in actual practice. Furthermore, real-world choices involve many different options that consumers select from, including a large variety of options for pricing, speed, data caps, latency, and more. Households in unserved areas have fewer options, which is a primary focus of this paper, but for purposes of estimating willingness to pay, part of the challenge to the analysis is how best to incorporate the wide variety of options. Furthermore, households also vary greatly in their usage rates (GB/month).

Recent economics literature has provided two complementary approaches to empirically grapple with these measurement problems. One method is to gather granular data on broadband usage under a variety of different observed conditions, and from that data extrapolate a map of consumer demand across a range of broadband speeds and options. This is the approach taken in two studies by economists Aviv Nevo, John L. Turner and Jonathan W. Williams (Nevo et al. 2016, 2015). Another method, taken by economists Yu-Hsin Liu, Jeffrey Prince, and Scott Wallsten, is to combine survey analysis with "discrete choice experiments" designed to elicit realistic responses, and to then build the demand curve with laboratory instead of observational data (Liu et al. 2018). Liu et al. discuss various approaches to estimating broadband demand. The major advantage of their approach for our purposes is the ability to estimate WTP at various speed thresholds, which available observational studies cannot do. Table 1 below presents our main findings, which we organize along three speed thresholds that are comparable to existing and planned broadband service plan offerings at the time of this writing. Appendix B below contains full details of the analysis, including alternative assumptions considered.

Beginning with the first row of Table 1, we present estimates of economic gains to a representative household. As the dollar amounts show, we calculate the household's estimated WTP at $89.94 per month to improve from Mobile 5/1 Mbps to Fixed 150/25 Mbps. Similarly, the estimated WTP is $100.06 per month for improvement from 5/1 to 300/100 Mbps, and $107.05 per month for improvement from 5/1 to 1000/100 Mbps. To calculate these estimates, we first begin with the separate WTP estimates for download and upload speed reported in Table 6 of the

Liu et al. study. For example, our calculation of $107.05 combines the Liu et al. estimated WTP of $82.59 for 1000 Mbps download, plus the separately estimated $24.46 for 100 Mbps upload speed. The combined WTP is $107.05 = $82.59 + $24.46. The other estimates in the first row of Table 1 below are calculated the same way. The second row simply multiplies these monthly gains times 12 to sum the annualized household gains. Estimates for the full range of speed thresholds reported in Liu et al are presented in Table B1 of Appendix B below.

To interpret these estimates in plain language, recall that WTP is also called reservation price. The $107.05 estimate, for example, is interpreted as the highest price that a representative household would pay to get improved access from Mobile 5/1 to Fixed 1000/100 Mbps. WTP therefore represents a dollarized measure of the value to that representative household of broadband's productive, commercial, social, educational, entertainment, health, civic and other benefits. Over the course of 12 months, these economic gains would sum to an annualized $1,284.60 per household, as reported in the second row of the table.

The middle rows of Table 1 report estimated statewide gains in both annualized and discounted present value terms. Our moderate estimate, in the middle column at 300/100 Mbps, assumes that all assigned RDOF locations are served and connected (Assumption 2A in Appendix B), which would yield a statewide annual economic gain of $186.3 million. If we instead assume less strongly that only 60% of locations are served (Assumption 2B in Appendix B), then our estimate of statewide annual gain is reduced, but is still a very substantial gain of $111.8 million. In present value terms, at the duration of 50 years, or approximately the upper range of average utility pole life, our estimates of the aggregate statewide economics gains range from $3.06 to $3.64 billion, assuming conservatively a 5% discount rate.

Table 1: Estimates of Economic Gains Generated by Full Broadband Expansion in North Carolina

	Assumptions	150/25 Mbps	300/100 Mbps	1000/100 Mbps
Typical Household WTP (per month)	1A	$89.94	$100.06	$107.05
Annual Gain to a Typical Household (WTP x 12)	1A	$1,079.28	$1,200.72	$1,284.60
Annual Aggregate Gain, North Carolina Households	2A 2B	$167.4m $100.4m	$186.3m $111.8m	$199.3m $119.6m
Present Value over 50 Years (upper range avg. pole service life)	3A	$3.06b	$3.40b	$3.64b
Present Value over 25 Years (lower range avg. pole service life)	3B	$2.39b	$2.62b	$2.81b
Foregone Economic Gains of Delayed Expansion (per month)	4	$13.9m	$15.5m	$16.6m

These estimates are conservative in magnitude because the underlying WTP estimates do not reflect higher broadband demand since Covid-19 or the high speeds being deployed in current expansion plans. As we discussed in Section 2 above, upload demand rose by 60% from March to December 2020, and the RDOF program was structured to incentivize deployment at high speeds including 1000 Mbps download. In addition, these estimates are conservative because we are only counting federal RDOF expansion, not other federal and state efforts such as North Carolina's GREAT program, NTIA, and ARPA as discussed above. If the underlying WTP estimates were available, we could account for increased demand since the pandemic, higher speeds currently being rolled out, and locations served under the state's GREAT program or any prospective federal program. Our estimates would be larger in magnitude, perhaps substantially so as future research may suggest. Furthermore, our estimates capture only the direct economic gains to the demand side, measured as consumer WTP, omitting any positive external effects of broadband on productivity, economic growth, job opportunities, and other known benefits to the local and regional economy. For these reasons, the true economic gain to North Carolina of full broadband expansion may well exceed our conservative estimate of $3.5 billion.

Some believe that the fair outcome is to allow pole owners, especially the smaller local ones, to charge broadband providers higher fees for access to a vital input they so badly need to provide service. However, as demonstrated in this section, this is a much less fair outcome from an objective overall societal welfare standpoint, because it reduces or delays consumer access to broadband service, resulting in substantial lost value to consumers.

6. Conclusion: Policymakers Can Readily Address the "Pole Problem" by Adopting Efficient, Statewide Policies to Ensure Timeframes and Costs of Pole Access are Just, Reasonable, and Fair in Accordance with the Public Interest

If not fully apparent before, the urgent, vital need to tackle the digital divide is now beyond evident in the current Covid-19 environment where access to high quality broadband service has become so essential in providing our citizenry with access to education, health, commerce, government, and public safety, and the means for their own livelihood. As shown in this paper, the potential magnitude of the economic harms to North Carolina households and businesses associated with a status quo where pole owners are free to exercise their market power by causing higher costs and delayed expansion of broadband in unserved areas, with negative spillover effects rippling throughout the state, is quite large.

Today's regulatory ecosystem governing broadband provider access to Coop and Muni poles in most rural unserved areas of the country, including here in North Carolina, is characterized by the absence of a uniform public interest-oriented policy. We can address this void by adopting consistent statewide policies aimed at reducing the transactions costs and delays imposed on third party broadband provider in connection with their required access to utility poles. Such policies are needed in order to incent more efficient, timely, accessible high-quality access to broadband deployment and provide a substantial, measurable public interest benefit.

Given the urgent need for the rapid deployment of broadband expansion into North Carolina's unserved rural areas, and the availability of existing state and federal funding for this purpose, the stakes for policy makers to be proactive in terms of enacting policies that mitigate the economic harms of the status quo, i.e., one in which pole owners exercise undue market power over access to poles and otherwise impede broadband expansion, and ensuring the maximum benefit of public infrastructure spending dollars, could not be higher.

Specific public policy prescriptions to best promote the public interest objective of timely and accessible high-quality broadband access will address and remedy both direct and indirect cost factors identified as entry barriers and other holdups to entry. These include: promoting an efficient and equitable cost sharing arrangement between new attachers and pole owners for the costs of pole replacement to keep costs for new attachers at efficient, competitive yet compensatory levels for pole owners (i.e., based on the net book value of the replaced pole) that recognize the pole owner's inevitable replacement of the pole as part of its normal utility operations; and establish reasonable time frames for permitting and make-ready so as not to create delay that slows broadband deployment and deters future broadband investment. Elements of a model template for best practices legislative policy solutions to the pole problem, especially in connection with pole replacements, is provided in the Appendix C to this paper.

Adopting these policies is necessary to reduce existing and inefficient high transaction costs of entry associated with monopoly type behaviors by the largely unregulated Coop and Muni pole owners that slows down the rate of current deployment and creates disincentives for future broadband investment. Policies that create a just, reasonable and fair pole access framework will benefit all in the long run, including the utility's own electricity customers as consumers of broadband, in the form of enhanced economic benefits and growth associated with ubiquitous broadband coverage, as well increasing the impact of state and federal money allocated for broadband.

The public interest standard applicable to utility regulation appropriately takes into consideration the significant spillover benefits to the consuming public and society-at-large associated with third party access to utility poles under reasonable rates, terms and conditions, including those applicable to non-recurring charges, which have come to the forefront given the barriers to broadband infrastructure investment they present.

Anti-competitive make-ready charges and fees of the direct and indirect variety as described in this paper, vis-à-vis the competitive market standard, operate just like an inefficient tax on broadband service. Except in this situation, the utility and not the government reaps the proceeds, and the large positive externalities of expanded broadband adoption (including among the pole owner's own electric customers) are lost. Even more troubling is that the utility-imposed surrogate make-ready "taxes" on attachers is in a growing number of cases being levied by a current or potential competitor as more and more utilities themselves enter or announce plans to enter the broadband market.[11]

[11] See e.g., https://www.roanoke-chowannewsherald.com/2019/05/15/roanoke-connect-receives-great-grant/

Consider the analogous situation where the government imposing the tax is not just incented by the monetary benefit of the collected levies, but also by the benefit of creating a distinct cost advantage to its own competing service. Even without the second anticompetitive benefit, acts by state and local governments in connection with their ownership and control of the public right of way essential facility that create an unfair and unbalanced regulatory environment for broadband providers have been found to materially inhibit the provision of service and hence create barriers to infrastructure investment.[12]

Given the underlying characteristics of poles and their necessity in rolling out broadband into unserved areas, policies that support a more favorable entry environment for broadband providers align with the public interest; conversely, the unfavorable entry conditions facing broadband providers today under the status quo which gives pole owners large discretion over rates, terms, and conditions of access, particularly as applies to make-ready work, holds up the public interest. As state and federal resources are used to support broadband expansion, the public interes in supporting a cost-efficient and timely pole attachment process is only heightened. Significantly, the public interest alignment of policies supporting favorable rates, terms, and conditions of access to poles for broadband providers takes into account the welfare of the utilities' own electric customers, who are also consumers of broadband.

In conclusion, this paper demonstrates why pole owner behaviors and the set of unjust and unreasonable make-ready rates, terms and conditions imposed on third-party broadband providers associated with those behaviors creates substantial deadweight loss to the people of North Carolina, especially those in rural unserved areas of the state. Allowing these behaviors to go unchecked is unreasonable and against a public interest standard, which compares outcomes under the status quo against the economic social welfare performance benchmark of an efficient, effectively competitive or well-functioning market outcome and allocation of societal resources. By measuring the foregone economic gains of delay or inaccessibility to high quality broadband to North Carolinians caused by pole owner barriers to infrastructure investment, especially those involving make-ready practices, this paper puts into context for policy makers the magnitude of the public interest benefit of the adoption of consistent, efficient policies, and the pressing case to do so.

[12] See *FCC Third Report & Order and Declaratory Ruling,* WC Docket No. 17-84 WT Docket No. 17-79, August 2, 2018, at pp.56 -57 (regarding harm of excess governmental ROW fees and distinctions between reasonable and balanced legal and regulatory environment, and unreasonable and entry inhibiting).

7. APPENDICES:

A. The Underlying Sources of Pole Owners' Market Power: A Combination of Hold Up Problems and Classic Barriers to Entry
B. Empirical Methodology and Results of High-Medium-Low Scenarios
C. Elements of a Model Pole Policy
D. Glossary of Technical Terms
E. List of Works Cited

Appendix A: The Underlying Sources of Pole Owners' Market Power: A Combination of Hold Up Problems and Classic Barriers to Entry

In order to make sound policy prescriptions, it is important to use economic analysis to identify the exact source of pole owner's monopoly power. The barriers to infrastructure investment are substantial and consistent with the qualitative and quantitative measures of classic entry barriers imposed by dominant firms well established in the economic industrial organization (I-O) literature and land use/assembly literature.

A.1 Barriers to Entry

The economic literature defines barriers to entry in terms of the "condition of entry" or "state of potential competition' from possible new sellers, and as emanating from sources including absolute cost advantages, product differentiation advantages, and advantages of scale enjoyed by the established firm vis-à-vis the new seller. (Bain 1965). Prior to Bain's seminal work, the condition of entry tended to be viewed in terms of two polar conditions, the first being free and easy entry versus the second being a condition of no entry. Bain developed an empirical framework under which both "height" and "character" of the condition of entry could be measured, and as a general proposition, industries receiving higher rankings with respect to specific and aggregate barriers to entry had blockaded or effectively impeded entry. With regard to the character of entry, the specific types or sources of entry identified by Bain have particular application to pole attachment charges, i.e., control of production techniques; imperfections in the markets for hired factors of production; specific limitations of the supplies of productive factors relative to the demands of an efficient entrant firm; and money market conditions imposing higher interest rates on potential entrants.

Economists following Bain, including Stigler and von Weizsacker (1980), make the following additional distinctions, aptly applicable to pole attachments as an essential facility needed to provide broadband service, as between barriers to entry the removal of which would be socially beneficial versus those that would not. In this key context, Weizsacker defines a barrier to entry as a cost of producing which must be borne by a firm which seeks to entry an industry but not the incumbent firm, and which implies a distortion in the allocation of resources from a societal point of view for which a "ideal" government, by reducing the barrier, could improve the allocation of resources.

A.2 The Hold Up Problem

The *hold up problem* is the power to impede others' ongoing investments. Hold up problems originate from the reality that market contracts are always naturally incomplete (Klein 1980 AER). In general, hold up problems arise in scenarios where Entity A makes an initial investment that is called "relationship-specific" because its return depends on Entity A subsequently contracting with Entity B. In these scenarios, if Entity B has information about A's investment, then B has sufficient bargaining power to extract rents from A's investment and thereby destroy economic value by requiring a high selling price (high, specifically, relative to what the selling price would be in absence of this market power).

In the context of current broadband expansion plans, the pre-assigned taxpayer funds represent Entity A's relationship-specific investment. Muni and Coop pole owners that extract rents by requiring economically unfeasible terms represent Entity B's inefficient hold up. Businesses and households incur the excess burdens of delay.
A top-selling textbook in the field of law & economics illustrates:

> Economic analysis suggests the following rule for duress: A promise extracted as the price to cooperate in creating value is enforceable, and a promise extracted by a threat to destroy value is unenforceable. To illustrate the rule, consider this example. The captain of a boat in California contracts with the crew to make a fishing voyage to Alaska. After the boat reaches Alaska, the crew demands a bonus to finish the voyage. The captain cannot find replacement for the crew in Alaska; so, he agrees. After the ship returns to California, the captain refuses to pay the bonus on the ground of duress.
>
> This example illustrates the form of duress called the *holdup problem*. When negotiating the original contract, the crew faced competition from other crews. After the boat reached Alaska, the crew no longer faced competition from other crews. The captain's reliance on the contract caused him to forego the opportunity of contracting with another crew in California. Furthermore, the captain made investments in reliance on the contract, such as purchasing fuel and supplies. The absence of competition and the captain's reliance on the crew increased the crew's bargaining strength. So, the crew tried to renegotiate the price.
>
> Notice that this example fits our distinction between legal demands and illegal threats. If the parties failed to agree on the original contract, they would not cooperate together. By failing to cooperate, they would not create a surplus. Renegotiation is different. After making the contract, the captain relied by foregoing the opportunity to hire an alternative crew and outfitting the boat for the voyage to Alaska. In the renegotiations, the crew threatened to destroy the value of the captain's reliance. The destructive threat to breach a contract after reliance constitutes coercion in renegotiating the price. In general, courts do not enforce contract renegotiations motivated by the increase in the promisor's bargaining strength that results from the promisee's reliance.
>
> Cooter & Uhlen (2004), *Law & Economics, 4th Edition*, p.271

In the current broadband expansion, taxpayers have exercised reliance on pole owners to achieve full broadband expansion. However, pole owners by extracting rents are destroying the value intended behind the taxpayer investments through GREAT, RDOF, and other policies intended to close the digital divide. Note that the deadweight loss of the hold up is not that Entity A must pay a high price. Rather, the *deadweight loss* is caused by Entity A's investment becoming economically unfeasible under the expectation that Entity B will threaten with delay.

A close cousin of the hold up problem, although not to be confused, is the holdout problem (Lopez and Clark 2013, Segersen and Miceli 2012). Classic applications of hold up problems have been explored across a range of circumstances, all of which involve ongoing contracts with pre-committed investments, as summarized by Klein (1998 New Palgrave). Hold up problems have been estimated to affect real estate values in greater Los Angeles, where prepared sites carry a premium of 20-40% over unassembled parcels (Brooks and Lutz 2016 AEJ Policy). The scope and real-world applicability of hold ups have been vigorously debated in contexts of trucking (Hubbard 1999), water supply (Foellmi and Meister 2012), and other network industries, and from a game theoretical perspective on hold up problems as well (Hermalin and Katz 2009). Recent work has applied the economics of hold ups to ongoing pole attachment issues in Georgia (Dunham 2020).

The hold up problems discussed above are a specific application of a larger market phenomenon well known in the in the economic Industrial Organization literature as entry barriers, that dominant firms in a market are able to exert on new entrants to impede the latter's ability to compete with the dominant firm. The make ready process applicable to pole attachments needed by broadband providers in order to roll out service in unserved lends itself to the classic IO paradigm of entry barriers. Through the make-ready process, pole owners have the opportunity and incentive to impose a number of direct and indirect cost and time related barriers on third party providers, if unchecked by policymakers - and also from the benchmark of the "ideal" government postulated in the IO theory, that good public policy would address in order to achieve a more efficient and equitable allocation of societal resources. There area number of direct and indirect cost/pricing factors that individually and collectively that serve as classic barriersto entry.

Appendix B: Empirical Methodology and Baseline / Alternative Assumptions

The estimates presented in this paper are based on calculations of consumer _willingness-to-pay_ (WTP), which is a bedrock concept in consumer choice theory and one of the core components of the theory of demand. WTP, also known in economics as _reservation price_, has been a fixture in economic analysis for nearly 150 years, as Alfred Marshall's classic 1890 textbook shows:

> ***To obtain complete knowledge of demand for anything, we should have to ascertain how much of it he [the consumer] would be willing to purchase at each of the prices at which it is likely to be offered; and the circumstance of his [the consumer's] demand for, say, tea can be best expressed by a list of the prices which he is willing to pay; that is, by his several demand prices for different amounts of it.*** **(Marshall 1920 [1st ed. 1890], p.81).**

WTP has been a fixture in economic theory ever since. The current edition of a top-selling textbook defines WTP as *"the maximum price a consumer will pay for a good; also called the reservation price"* (Mateer & Coppock 2020, p.153). WTP is a measure of gross consumer value received.

Consumer surplus (CS) is a measure of net value. Arithmetically, consumer surplus (CS) is simply the difference between the price that a consumer pays and the gross value that the consumer receives, the latter measured as WTP.

Definition: (CS) = (WTP) – (Price Paid).

Both WTP and CS are dollar measures of the gains to consumer welfare that offer valid methods to estimate the public benefits of expanding broadband access and the costs of delayed expansion.[13]

- **Baseline Assumption 1A:** Gross consumer welfare calculated as WTP measures the societal gains created by current broadband expansion plans.

- **Alternative Assumption 1B**: Net consumer welfare calculated as CS relies on observations or estimates of price paid that are not available for speed thresholds analyzed in this paper.

Due to the absence of a sound price paid estimate, Table 1 above and Table C1 below report only the WTP calculations corresponding to Assumption 1A.

B.1. The Representative Household's Monthly and Annualized Gains

Begin with a currently unserved representative household, and calculate the household's gain in consumer welfare from acquiring high-quality broadband access, as follows:

d_{hit} = the gained benefits as WTP or as CS to household (h), in county (i), in month (t).

This variable, d_{hit}, represents the increased value to a household of upgrading from mobile access at 5/1 Mbps to fixed terrestrial wireline access at high-quality speeds, namely the alternative thresholds reported in Table 1 above and Table C1 below.

[13] Classic studies in economic theory that use WTP to position CS as an appropriate measure of social welfare, in particular the welfare effects of market failures and corrective public policies, include Tullock (1967), Posner (1975), and Willig (1976). Selections of recent work that use WTP to calculate CS as the measure of welfare effects of public policies include Beard et al. (2020), Allcott and Sunstein (2015), and Owen (2011).

Recent work in theoretical and applied economics provides a clear basis for estimating d_{hit}. For example, Nevo, Turner, and Williams (2015, 2016) and Liu, Prince, and Wallsten (2018) estimate a representative household's WTP for various speeds and other plan features. The Nevo et al. papers are based on observation of market data where the household's internet usage is observed at various prices paid; therefore, those authors are equipped to calculate CS to estimate welfare gains. On the other hand, the Liu et al. study is based on laboratory data generated by discrete choice experiments and survey analysis. Unlike observational studies, the discrete choice experiment method equips Liu et al. to estimate WTP, which is not observed in market pricing or usage data.

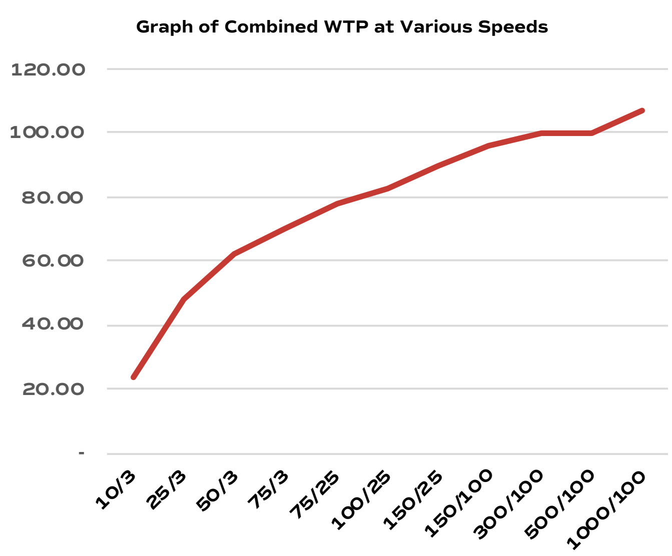
Liu et al. provide separate estimates for download and upload WTP, reporting the following dollar amounts that a representative household would be willing to pay for an increase from 4 Mbps download to the listed faster speeds, and separately from 1 Mbps upload to the faster speeds listed.

Download Speeds	Estimated WTP
10 Mbps	$14.01
25 Mbps	$37.63
50 Mbps	$51.80
75 Mbps	$59.70
100 Mbps	$63.82
150 Mbps	$71.37
300 Mbps	$75.60

Download Speeds	Estimated WTP
500 Mbps	$75.47
1000 Mbps	$82.59

Upload Speeds	Estimated WTP
3 Mbps	$10.01
25 Mbps	$18.57
100 Mbps	$24.46

To adapt the above separate estimates for the purposes of this paper, we select 11 combinations of d/u speeds and sum them to calculate combined WTP for faster download and upload speeds.



Speeds (download/upload)		Combined WTP
10/3	**Mbps**	$24.02
25/3	**Mbps**	$47.64
50/3	**Mbps**	$61.81
75/3	**Mbps**	$69.71
75/25	**Mbps**	$78.27
100/25	**Mbps**	$82.39
150/25	**Mbps**	$89.94
150/100	**Mbps**	$95.83
300/100	**Mbps**	$100.06
500/100	**Mbps**	$99.93
1000/100	**Mbps**	$107.05

The graph shows that the combined WTP curve becomes flatter at faster speeds, thus reflecting the fundamentally realistic feature of diminishing marginal returns in the demand for internet speed.

The household's annualized gain in year y is the sum of 12 monthly gains, or $d_{hiy} = 12 \times d_{hit}$.

B.2. Aggregating to County and State Annualized Gains

Define the variable $\hat{S}_T$ as the discounted present value of aggregate new WTP, or alternatively aggregate new CS, that would be created by current broadband expansion plans.

To operationalize aggregation from the representative household's annualized d_{hiy} to the state's gain of $\hat{S}_T$, we assume deployment and adoption rates as follows.

- **Baseline Assumption 2A**: all 155,137 assigned RDOF locations in North Carolina gain access and adopt service.
- **Alternative Assumption 2B:** only 60% of those 155,137 locations gain access and adopt service.

Under either Assumption 2A or 2B, the household's gain of dhit easily aggregates to the county level as follows.

$D_i = (d_{hit}) \times (H_i)$, where H_i is the number of households or businesses in county *i* as defined by Assumption 2.

We then aggregate to the state level by simply aggregating North Carolina's 100 counties.

$\hat{S}_T$ = Sum(*i*=1-100) D_i, which is the annualized aggregate new consumer welfare that current expansion plans would be created statewide.

B.3. Discounting to Present Value

To reflect the sustained creation of new value over time that current broadband expansion plans would impart, we calculate the discounted present value of the above annualized gains, $\hat{S}_T$. We initially assume a 5% discount rate over 50 and 25 years respectively, and then in perpetuity.

- **Assumption 3A**: discount rate is 5% over 50 years (upper range of the average pole service life)
- **Assumption 3B:** discount rate is 5% over 25 years (lower range of the average pole service life).
- **Assumption 3C:** discount rate is 5% in perpetuity.

The baseline assumption of perpetuity assumes continuity of service, similar to Connolly (2020, p.13). The alternative assumptions are based on average pole service life as discussed in Kravtin (2020, p.34), "poles are long-lived assets, with average service lives ranging from 25 to 50 years if not longer." Table 1 above reports estimates of present value under these alternative assumptions as follows.

3A: $\mathbf{PV\hat{S}_T 3B} = \sum_{t=0}^{50} \frac{\hat{S}_T}{(1+.05)^n}$ 3B: $\mathbf{PV\hat{S}_T 3C} = \sum_{t=0}^{50} \frac{\hat{S}_T}{(1+.05)^n}$ 3C: $\mathbf{PV\hat{S}_T 3A} = (\hat{S}_T) \div (.05)$

where n represents each year from t=0 to N=50 or N=25. This variable, $PV\hat{S}_T$, represents the present value of all future annualized benefits that North Carolina households would experience by achieving full broadband access.

B4. Delay Cost Methodology

To calculate delay costs, we make the following

- **Assumption 4:** Foregone WTP per month measures deadweight loss.

Table B1: Estimates of Economic Gains Generated by Full Broadband Expansion in North Carolina – Complete Results

	Typical Household WTP (per month)	Annual Gain to a Typical Household (WTP x 12)	Annual Aggregate Gain, NC Households	PV over 50 Years (upper range avg. pole service life)	PV over 25 Years (lower range avg. pole service live)	PV of Aggregate Gain in Perpetuity	Foregone Economic Gains of Delayed Expansion (per month)
Assumption	1A	1A	2A 2B	3A	3B	3C	4
10/3 Mbps	$24.02	$288.24	$44.7m $26.8m	$816m	$630m	$894m	$3.7m
25/3 Mbps	$47.64	$571.68	$88.7m $53.22m	$1.62b	$1.25b	$1.7b	$7.4m
50/3 Mbps	$61.81	$741.72	$115.1m $69.06m	$2.10b	$1.62b	$2.3b	$9.6m
75/3 Mbps	$69.71	$836.52	$129.8m $77.8m	$2.37b	$1.83b	$2.5b	$10.8m
75/25 Mbps	$78.27	$939.24	$145.7m $87.4m	$2.66b	$2.05b	$2.9b	$12.1m
100/25 Mbps	$82.39	$988.68	$153.4m $92.0m	$2.80b	$2.16b	$3.1b	$12.8m
150/25 Mbps	$89.94	$1,079.28	$167.4m $100.4m	$3.06b	$2.39b	$3.3b	$13.9m
150/100 Mbps	$95.83	$1,149.96	$178.4m $107.4m	$3.26b	$2.54b	$3.5b	$14.9m
300/100 Mbps	$100.06	$1,200.72	$186.3m $111.8m	$3.40b	$2.62b	$3.7b	$15.5m
1000/100 Mbps	$107.05	$1,284.60	$199.3m $119.6m	$3.64b	$2.81b	$3.9b	$16.6m

Appendix C: Elements of a Model Pole Policy for Pole Replacements

Two foundational principles necessary for the success of broadband deployment in unserved areas are: 1) changing the cost equation for the intermediate pole input in order to encourage infrastructure investment in hard-to-reach areas of the country; and 2) the removal of other regulatory or market impediments to the vital pole input that might jeopardize the cost-efficient nature of that infrastructure investment and deployment. These two principles are at the forefront of the effort to achieve full broadband access in North Carolina. The first policy priority is being addressed by federal and state programs that seek to support the cost-efficient deployment of broadband in hard to serve areas of the country; however, the second priority requires additional policies, including policies to ensure an economically efficient and fair cost allocation of pole costs that would help to moderate a pole owners' ability to exercise anti-competitive, anti-consumer market power in an otherwise competitive ecosystem.

Key elements of urgently needed broadband deployment promoting policies include:

- Definitions for make-ready related pole replacements that distinguish make-ready pole replacements from those related to the utility's own inevitable electric (or broadband related) infrastructure upgrade costs;
- Terms that provide for the economically efficient and equitable sharing of costs of pole replacements tied to the age and/or net book value of the utility poles to be replaced that would preclude, as precondition of access, new attachers from having to bear the full cost of replacing aging poles the utility would have to replace at its own cost in the near future in the absence of the new attachment or overlash;
- Terms that facilitate the efficient use of federal and state grant funding;
- Detailed make-ready related invoices;
- Specify workable time frames for pole permit application, survey timeframes, pre and post construction requirements;
- Shorter timelines for make-ready work;
- Shorter timelines for existing attachers whose facilities are slated for OTMR versus the timelines for assessing new attacher OTMR requests;
- Audit process and costs;
- Reasonable notice-only policy for overlashing;
- Terms that preclude as precondition of access prior to overlashing, requirement for permitting or fixing of preexisting violations;
- Expedited dispute resolution under the auspices of the state utility commission or through the courts subject to applicable law; and
- Recurring rental rates set based on the widely used FCC cable rate formula.

Appendix D: Glossary of Technical Terms

Barriers to Entry – "Factors that increase the cost to new firms of entering an industry" (Cowen & Tabarrok 2021)

Consumer Surplus – "The consumer's gain from exchange, or the difference between the maximum price a consumer is willing to pay for a certain quantity and the market price" (Cowen & Tabarrok 2021)

Deadweight Loss – "the reduction in total [consumer] surplus caused by a market distortion or inefficiency" (Cowen & Tabarrok 2021)

- Example: If a household would gain $100 of WTP, but it remains unconnected because of the holdup problem, then the deadweight loss is equal to the foregone economic gain of $100.

Economic Efficiency – "Productive efficiency concerns the utilization of resources to achieve the highest possible level of production of a desired mix of goods and services [and] distribution of goods and services in an economy to maximize social welfare." (Cole & Grossman 2005, p.10)

Hold Up Problem – the use of market power "to extract by a threat to destroy value" that impedes other's ongoing investments (Cooter & Uhlen 2004, p.271)

Intermediate Goods – "resources that are used in the production process to make other goods, which are ultimately sold to consumers" (Investopedia.com)

Natural Monopoly – "a situation when a single firm can supply the entire market at a lower cost than two or more firms" (Cowen & Tabarrok 2021)

Non-Rival in Use – "when one person's consumption of the good does not limit another person's consumption" (Cowen & Tabarrok 2021)

Public Goods – "goods that are nonexcludable and nonrival" (Cowen & Tabarrok 2021)

Public Interest – "the efficient quantity is the quantity that maximizes social surplus" (Cowen & Tabarrok 2021)

Willingness-to-Pay – the economic value of something is how much someone is willing to pay for it" (Posner 1992, p.12). Also, "the maximum price a consumer will pay for a good; also called the reservation price" (Mateer & Coppock 2020, p.152)

- Example: If a currently unserved household were willing to pay $100 to improve from a low quality connection at slow speeds to a high-quality broadband connection at high speeds, then we say that the household values this broadband improvement as much as it values $100 of other goods & services.

Appendix E: List of Works Cited

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