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Closing the Digital Divide: A Historic and Economic Justification for Government Intervention

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Summary:

Access to high-speed Internet is essential for full and consequential participation in the civic, economic, and education systems of modern life. According to the Annual Broadband Adoption Survey, approximately 30% of Californians continue to lack "meaningful internet access" at home, creating a Digital Divide that is worse among already disadvantaged communities. As recent efforts have made access to the necessary broadband infrastructure near ubiquitous, this indicates alternative barriers to expanding the adoption of broadband technology. We explore the economic benefits of broadband adoption and historical precedence of government investment in utility infrastructure and adoption, arguing that government support for broadband must move beyond infrastructure deployment to further household adoption. We develop a framework for thinking about broadband adoption, applying it to the case of California to generate policy recommendations.

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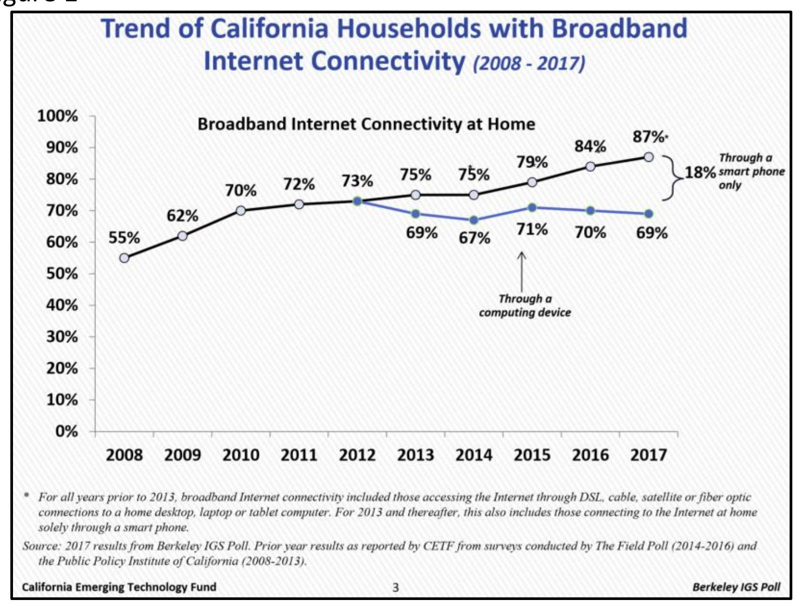
1. INTRODUCTION

Access to high-speed Internet is essential for full and consequential participation in the civic, economic, and education systems of life in California in 2018. From business to government, information and services have moved to the internet, and the increasing complexity of apps and web sites mean much of the content is only available to those with a broadband connection. Those needing information—students, job seekers, citizens in a democracy—find the vital services of modern life much more effectively and conveniently accessed via the internet, and those without access often face hardships invisible to the connected majority. Figure 1 below shows that, despite California being the birthplace of many of the most well-known and ubiquitous internet companies (Google and Apple, Oracle, Facebook, etc.), 31% of the California population continues to lack at least two of the three components of "meaningful internet access" at home.

Figure 1



(Berkeley IGS Broadband Adoption Survey - 2017)

Meaningful Internet Access

"Meaningful internet access" is a dynamic concept that addresses the functionality of the technology, requiring the combination of internet service, the necessary computing equipment, and the necessary digital literacy skills. If any one of those three elements are missing, a person cannot be said to have meaningful internet access. Specifically, in order for a consumer to have "meaningful internet access" they must have three things:

(1) A reliable broadband internet connection with speed sufficient to meet the Government's minimum definition of service;

(2) A computing device capable of providing sufficient functionality and computing power to support prevalent consumer applications at any given point in time. The device needs to be

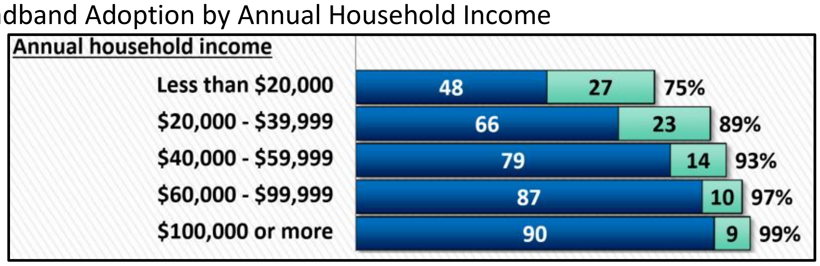
sufficient for a consumer to be able to utilize the technology to save time and money when using it as a tool for employment, education and government access.[1]

(3) The "digital literacy" skills necessary to utilize the programs and navigate the internet, sufficient for a consumer to utilize the use of technology to engage with online opportunities and services to improve their quality of life.

While 31% of Californians lack meaningful internet access, that number can be split into two main and distinct groups; those who have "network access", and those who don't. Due to the challenges and expense of deploying broadband infrastructure to remote and rural areas there are many areas of California, as with other states, where the physical infrastructure simply does not exist or is inadequate due to outdated, slower technology. Network access is independent of personal income level, i.e. those who live in rural areas without network infrastructure are unable to connect regardless of ability to pay. As such, they shouldn't be considered in the same context as those who have network access but lack the ability to pay the service fee. Those who lack network access fall into two groups, 1) those who are **UN**served, and 2) those who are **UNDER**served. Unserved individuals lack access to ANY broadband infrastructure, while those who are underserved have access to infrastructure that does not meet the current government definition of being served. According to the 2017 CASF Annual Report from the California Public Utilities Commission there are a combined 618,719 California households that are unserved and underserved (325,955 are underserved, and 292,764 are unserved) (CPUC, 2017a). Combining the CPUC data with the data underlying Figure 1 above shows that there are 3,882,584 households in California that lack meaningful internet access, with 16% of that number coming from households (618,719) being in unserved or underserved, rural areas. As a percentage of all California households, lack of network access accounts for just 4.78% of the total Digital Divide.

Lack of meaningful internet access is at 25.22% in areas where network access issues are not an impediment. In those areas lack of household income is the biggest impediment as seen in Figure 2. Data from the 2014 – 2017 research polls[2] conducted for the California Emerging Technology Fund (CETF) shows that in addition to income disparities the disconnected typically belong to socioeconomic groups that historically face significant hardships and disadvantages. In 2017 for example, 40% of Californians living in the more rural "Inland Counties", 61% of those who didn't graduate from high school, 46% of Latino households, and 40% of people with disabilities lacked broadband internet access at home.

Figure 2: Broadband Adoption by Annual Household Income



Additionally, these groups are far more likely to rely on a smartphone for their internet access (Berkeley IGS, 2017). With data caps, miniature keyboards, small screens, and less than full versions of

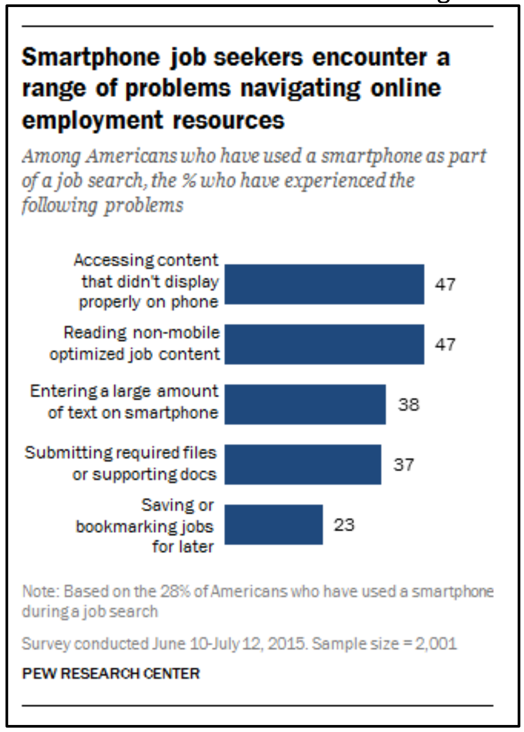
[1] As of the writing of this paper, to meet this definition, a computing device would need to have a separate, full QWERTY keyboard, and a screen size large enough to run full versions of common word processing programs and internet browsers. This definition may change over time as alternate technologies and input methods are developed.

[2] The CETF annual adoption survey began in 2008 and was conducted by the Public Policy Institute of California. In 2014 it was moved to the Field Poll and number of questions increased. The Field Poll closed in 2017 and the 2018 survey was conducted by the UC Berkeley IGS.

word-processing and other essential programs, smartphones fail the test to meet the definition of an appropriate computing device. While those without meaningful internet access are negatively impacted in a variety of ways, (education, access to government, etc.) the focus of this paper is to assess the economic impacts of the Digital Divide, and the potential benefits of government investment in internet infrastructure deployment and adoption programs.

At the microeconomic level, insufficient access to broadband manifests itself in hardships for individuals in our society. For example, recent research from the Pew Research Center on the Internet, Science, and Technology found that 79% of recent job seekers in the United States used the internet to assist them in their search (Smith, 2015). The study finds that individuals who use the internet to assist in finding and applying for employment realize a number of benefits that similarly situated individuals who don't use internet do not, including finding employment more quickly and staying employed longer. Additionally, employed individuals who use the internet to search for a new position are more likely to be successful in that endeavor than those who don't use the internet (U.S., 2016).

Figure 3



Smartphones are seen by many as an acceptable device for those who cannot afford multiple devices. And, smartphones do provide a level of functionality that is clearly beneficial. However, Pew Center data shows that those who lack appropriate computing equipment face similar problems to those who lack broadband connectivity. Tasks such as creating a resume, using the web to search for available positions, filling out online applications, and contacting employers are reported as much more difficult when job-seekers' only internet access is via smartphones, emphasizing the need for meaningful internet access. As illustrated by Figure 3, those whose only internet access is via smartphones face the same challenges (Smith, 2015). Given these findings and their comparatively limited functionality smartphones should be considered a supplement to computers and not a replacement for them.

To be clear, while the Digital Divide is closely correlated with lower individual and household income, it is obviously not the cause of it. Rather it is a consequence of a greater economic vulnerability. That said, even without the causal relationship, individuals who have meaningful internet access also have the tools to gain better individual economic outcomes, and it can be reasonably inferred that those who gain meaningful internet access will also gain the same access to improved prospects in the workforce.

At the macroeconomic level, research shows positive economic multipliers associated with government investment in infrastructure. Qiang et al. (2009), in a study for the World Bank, found that an increase in broadband access of 10 percentage points was correlated with a 1.3 percentage point increase in economic growth in high-income economies. As of 2006, the shift from dial-up internet access to broadband internet access contributed \$8.3 - \$10.6 billion of incremental U.S. gross domestic product (Greenstein and McDevitt, 2011).

Historically, government (federal and state) has engaged in regulatory oversight of public utilities, working to ensure physical infrastructure was deployed to all. Additionally, public utilities have historically been natural monopolies as the cost of deploying infrastructure was so high it discouraged competition. As a result, governments also exerted regulatory oversight to ensure price gouging did not occur. However, with limited exceptions, "…the US (and California), have relied more heavily on unfettered market forces," (Bauer, 2010) with broadband technologies being deployed in a competitive marketplace by multiple fully capitalized companies, such as AT&T, Comcast, Time-Warner, Verizon and others. But as the Figure 1 above shows, wireline broadband adoption in California has leveled out at approximately 70%.

Because there is a competitive market for broadband access in the majority of California, private providers have an incentive to create the infrastructure necessary to sign up as many customers as is profitable to them. But as data from the 2017 Broadband Adoption Survey reveals, gaps in broadband adoption exist almost exclusively in California's rural areas and low-income communities. These communities either lack ability to pay for the services of telecommunications companies or lack access because it is too costly for the companies to reach them. We argue here market forces alone are no longer enough to get broadband internet into the vast majority of California homes that still do not have it in 2018. As such, we believe that if a governmental entity has or establishes a goal of closing the Digital Divide, government intervention in some form is necessary to achieve the goal.

Before establishing a policy goal of closing the Digital Divide, it is important to know if government intervention in this matter is justified. We summarize the benefits that accrue to all Californians – not just the households that will receive a new broadband internet connection – by connecting these remaining households. We accomplish this by first looking at the history of utility deployment and regulation, exploring the policy precedents of public investment in private utility infrastructure. We pay particular attention to the electricity grid and the telephone communications network, examining the similarities and differences between the deployment of the two, as well as "adoption" programs to make electricity and telephony services affordable to low-income individuals. This historical perspective provides context, showing that our policy recommendations are not radical departure from current and historical public policy and practice.

The Federal Government's American Recovery and Reinvestment Act's (ARRA) broadband funding and the California Advanced Services Fund (CASF) are analyzed to see how those programs were structured, assessing the effectiveness of each as a tool for broadband deployment and adoption. In addition, we utilize data from the 2017 Annual Broadband Adoption Survey to understand the size and implications of the Digital Divide in California. Data about broadband penetration and usage is combined with data from the ARRA and CASF programs to look at the total estimated economic benefits derived from public investment in broadband infrastructure deployment, and low-income, broadband adoption assistance programs.

Although broadband infrastructure is a new technology, in the early 2000s a literature developed regarding the economic benefits of broadband deployment. These writings are discussed, reflecting how the benefits and their estimated impact may have changed with the technology and extent of deployment and adoption over the past decade. An analysis of the ARRA (federal) and CASF (state) programs and grant expenditures provide the necessary data to conduct a rough, cost-benefit analysis. This is followed by the development of a policy framework, policy recommendations and finally concluding thoughts. Together, the understanding developed here provides a rational basis for our policy recommendations, including authorizing additional funding for broadband infrastructure deployment and adoption assistance programs, the initial premise being that public investment in such programs is sound public policy because it:

(1) Offers significant benefit to the households who are directly impacted by the interventions;

(2) Has significant public benefit to society overall;

(3) Is a prudent use of public funds that yields economic impacts significantly greater than the amount invested;

(4) Is not achievable with private sector funds alone; and

(5) Has broad public support as a policy goal.

For clarity, as the readers of this paper will vary widely in background, we start with a discussion of the basic terms so that common meanings and definitions are understood.

2. DEFINITION OF KEY TERMS

A common understanding of terms and definitions specific to this policy area is imperative, yet often lacking. While many of the terms used are familiar in a general sense to policy makers at large, many have specific meanings when it comes to technology, current policy, and the existing literature. Conceptually, policy makers (who are often ordinary citizens, with no special technical knowledge, elevated to an elected position and empowered to make decisions) may know the term "broadband" refers to higher speed internet access. However, they may be unfamiliar with the specific – and slightly varied – definitions attached to the term by regulatory bodies, the industry, and researchers. Additionally, policy makers and advocates alike often use terms like "access", "internet access" and "meaningful internet access" interchangeably, even though each has a specific, nuanced meaning. Even the term "Digital Divide" carries different connotations with different people – including among the experts. As this paper, along with policy decisions, depend on and are affected by the specific meanings of these terms, it is necessary to make these definitions explicit.

Dial-Up

In 2018 the term "broadband" is synonymous with "the Internet" for most people. But it wasn't always that way. In the early 1990s, as the internet began to gain widespread commercial appeal, the predominant method of accessing the internet was through a "dial-up" connection using a modem. Early modems were external to computers, and users would put the handset of their telephone into the modem's cradle. The modem would dial the number of an Internet Service Provider (such as AOL) and the two computers would connect to each other and communicate using a series of computer generated tones. The difference in functionality between dial-up and broadband is dramatic. Whereas a 1mb file (equivalent to a small photo) can be emailed or downloaded nearly instantly on broadband, the same file would take minutes to send or receive via dial up. Graphics laden, complex, and interactive websites that are common today would have been impossible with dial up.

The first breakthrough improving the speed of the internet connection was to make the modem internal to the computer, creating a plug where a phone wire could plug directly into the computer. From there dial-up modem speeds doubled frequently, however the fastest dial-up speeds could never approach broadband's capabilities. While dial-up internet access is mostly a thing of the relatively recent past, some households continue to rely upon dial-up modems for their internet access. In 2013, Pew reported that 3% of the US population uses dial-up modems (Pew Internet, 2013), and more recently, the 2016 Annual Broadband Adoption Survey showed 1.1% of Californians still use dial-up modems to access the internet (Field Poll, 2016).

Broadband

In California, there are two different regulatory authorities: (1) the Federal Communications Commission (FCC) which oversees telecommunications policy, including broadband, at the federal level, and (2) the California Public Utilities Commission (CPUC) which has regulatory authority over telecommunications and broadband services in California, to the extent it is not preempted by federal law. Each of these entities has a different definition of the speed necessary to qualify as "broadband." These entities update their definitions over time to reflect advancements in technology and necessary functionality.

In 2010, for the National Broadband Plan, the FCC instituted a broadband speed benchmark of 4 Megabits per second download and 1 Megabit per second upload (4 Mbps/1 Mbps). In January of 2015 they adopted the recommended definition of the 2015 Broadband Progress Report and Notice of Inquiry on Immediate Action to Accelerate Deployment. In that report, the Commission found the record could no longer support the existing speed benchmark as it did not provide sufficient bandwidth to allow consumers to effectively use the broadband services widely available. Further the Commission found the 4 Mbps/1 Mbps would not enable more advanced services. The Commission found the record supported a significant leap forward in the benchmark broadband speed and instituted a new benchmark of 25 Mbps/3 Mbps. The Commission stated, "We have recognized that the concept of broadband does not stand still, but instead must evolve and after a new and updated review of the market, we find that a speed benchmark of 25 Mbps/3 Mbps best captures the statutory definition envisioned by Congress." (FCC, 2015). The 25 Mbps/3 Mbps standard adopted by the FCC is not the standard to determine if an area is served, but rather to define what is needed for "Advanced Telecommunications Capabilities". It is what the FCC believes is necessary but is not currently used as a definitional standard or requirement. There is a third standard, 10 Mbps/1 Mbps, which is the speed requirement of the Connect America Fund round two grants (FCC, 2014).

The definition of served broadband is California is clearer. On June 12, 2008, the CPUC enacted Resolution T-17143, which "adopts the application requirements, timelines, and scoring criteria for parties to qualify for broadband project funding under the California Advanced Services Fund (CASF)." This Resolution established the initial California standard for served broadband of 3 Mbps/1 Mbps. In enacting the standard, "the Commission sought to establish a reasonable benchmark to effectively work from home given current uses of the Internet to download video and data, while providing a reasonable balance of technology, engineering and costs as of the end of 2007." (CPUC, 2008). This was significant, as it not only looked at the physical capabilities of the technology but also took into account the end user's needs to participate in civic life.

The Commission revisited the issue of suitable broadband speed on February 1, 2012 when they approved Decision 12-02-015. That decision, among other things, created the California's current definition of "broadband," defining households as "Underserved" if "…broadband is available, but no wireline or wireless facilities-based provider offers service at advertised speeds of at least 6 mbps download and 1.5 mbps upload." (CPUC, 2012). This definition was amended slightly by Assembly Bill 1665, the most recent reauthorization of CASF (California Law, 2017). AB 1665 defines "unserved" as areas lacking least 6 mbps/1 mbps. However, like federal Connect America Fund II (CAF II) program, discussed in detail in a later section, CASF requires a speed of 10 Mbps/1 Mbps to be eligible funding.

The federal and state definitions of served are slightly different, however the practical effect is minimal. Households with speeds that fail to meet the California definition usually don't miss by 1 Mbps, usually they are well under. Similarly, those who have service that exceeds the 6 Mbps definition usually exceed it by several megabits per second, if not more. As this paper focuses on the Digital divide in California and conducts calculations based on California data we use the current California definition of 6 Mbps/1 Mbps to determine if an area is unserved or underserved. To put these speeds in context, the major commercial broadband providers standard residential offerings in urban areas of California have download speeds ranging from 10 mbps to 75 mbps, with some companies offering speeds well in excess of 100 mbps.

In addition to understanding the government standards for broadband speed, it is important to recognize the functionality it has enabled. Broadband stands in stark contrast to the slower speeds of dial-up and has allowed for exponentially faster data transfer speeds. The advanced speeds then enabled the creation of more complex and interactive websites, as well as even more advanced services such as streaming audio and video – which in turn enabled services like Netflix, Pandora, and Facebook Live, as well as distance learning, and the streaming of government meetings. Broadband service can be provided by a number of technologies, including wireline, fixed-wireless, mobile, and satellite. However, regardless of the technology, reliability and speed is paramount for the consumer and therefore for policy makers.

<u>Access</u>

The CPUC defines "access" as, "…the ready availability of broadband services such that a household may subscribe to an Internet Service Provider." (CPUC, 2016). While accurate, this definition is limited as lack of access is also used in a looser, more colloquial sense to describe a general inability to connect to the internet, whether due to a lack of infrastructure or because the consumer has chosen or are not able to purchase the service. The CPUC definition of access refers simply to the physical infrastructure necessary to bring broadband into a home, apartment, school, library, or workplace. For our purposes, a community can lack access in the strict, network sense of the word because they are either "unserved" or "underserved". We use the term "Unserved" to mean broadband is physically not available to the consumer as the broadband infrastructure does not exist to connect that community. An "underserved" community has internet access, but at speeds too slow for properly transmitting the amount of data necessary to have meaningful functionality, as defined by the CPUC or FCC.

<u>Adoption</u>

In contrast to access, the concept of "adoption" refers to a consumer signing up for broadband from an Internet service provider (either stand-alone or as part of bundled service). In urban areas the infrastructure to provide broadband exists, so consumers have access. Consumers in such environments who do not purchase the available service are said to not be adopting (as opposed to the concept of "early adopters" who are the first to purchase new technologies). This is an important distinction from those who, primarily in rural areas, do not have broadband in the home due to a lack of access to the necessary infrastructure. Numerous studies, including the 2017 IGS Berkley poll cited throughout this paper, have shown that many low-income households do not adopt broadband because the cost of the necessary computing device and the monthly fees are more than they can afford.

Digital Divide

The "Digital Divide" is the term commonly used to describe the divide between those who are able to access the Internet via a home broadband connection and those who don't. The California Emerging Technology Fund (CETF), an organization whose mission and purpose (of creation) is to close the Digital Divide in California, considers the Digital Divide "as the condition when significant segments of the population do not have access or are not using technology at the same rate and manner as the average—there are wide differences in the access to and use of high-speed Internet service."(CETF, 2008). While there is no official government definition of the Digital Divide, CETF says they apply a "general rule in statistical variation in populations, and a "divide" exists if any segment of the population is 10 percentage points or more away from the population as a total (or average)." (CETF, 2008).

In recent writings, one of the authors of this paper (Levine) has begun using a secondary term: "meaningful internet access" (as discussed in Section 1, above). In this paper, we introduce that term into the formal lexicon of closing the Digital Divide, as we see the term as a further and more complete descriptor of the Digital Divide. In keeping with the notion that "access" refers to the physical infrastructure necessary to connect to the internet, meaningful internet access additionally accounts for the type of device a person uses to access the internet and the skills necessary to effectively engage the technology, broadening the concept of access beyond the necessary infrastructure. It accounts for the full compendium of technologies, services, and skills a person needs to connect to the internet and successfully use it for education, employment, or civic engagement endeavors.

The move from dial-up to broadband was significant in that it allowed more data to be transferred significantly faster and at an accelerating rate, providing consumers and businesses with more tools and functionality. Recognizing that shift, the FCC and the CPUC have continually updated their definitions of what constitutes acceptable broadband speed. However, as the technology improved there developed a Digital Divide where some had access to the infrastructure, computing devices, and education to fully utilize the internet, and others did not. The high-cost of deploying the infrastructure in rural areas meant that residents of those areas were among the last to get access to broadband, and many still don't have access to infrastructure. In urban areas, the cost of the monthly subscriptions and the computing equipment necessary kept many of those residents off the internet. Recognizing the importance of internet access for daily life, not-for-profit organizations and government entities began to develop policies and programs to help bridge the Digital Divide and provide all people meaningful internet access. And that concept, more than any of the others, is what policy makers need to focus on ensuring. As discussed below, in the 21st century, those without meaningful internet access are at a significant disadvantage.

3. A BRIEF HISTORY OF PUBLIC FUNDING OF UTILITY INFRASTRUCTURE IN THE UNITED STATES

California Public Utilities Code, section 216. (a) defines a "Public utility" as such:

> "Public Utility" includes every common carrier, toll bridge corporation, pipeline corporation, gas corporation, electrical corporation, telephone corporation, telegraph corporation, water corporation, sewer system corporation, and heat corporation, where the service is performed for, or the commodity is delivered to, the public or any portion thereof.

The most often thought of public utilities are electricity, natural gas, and telephone service, but as the statutory definition shows, the list is considerably longer. A distinguishing feature common to such entities is the requirement of large investments in infrastructure to deploy their product to large customer bases spread over a large geographic territory. With large capital-intensive projects such as the construction of electric transmission lines or railroad tracks, the existence of economies of scale for many utilities have resulted in natural monopolies, as it is more efficient, practical, and cost effective to have only one company provide such a service in a given territory.

While historically the case, not all public utilities can be characterized in such a way today. This is particularly true for the provision of telecommunications and data services in urban areas, where there is often significant competition amongst providers. This is, in part, due to telecommunication firms expanding the breadth of services offered. For example, whereas providers of telephone services and cable video services used to be distinct, companies such as AT&T, which historically provided land-line phone service only, now also provide video and broadband service. Similarly, companies like Comcast, which historically only provided video service, now also provide voice and broadband services as well. Mobile phone companies also participate in the market, offering voice, video, and broadband services. In rural areas, however, because the cost of infrastructure deployment is higher and the return on the investment lower, consumers in those areas lack competition and many lack any access to broadband services.

We focus primarily on the history of public investment in private infrastructure, providing the historical precedent for current public investment in private broadband infrastructure deployment programs and adoption efforts. While utilities may be publicly or privately owned, the difference is immaterial for this paper as the focus is on precedent and value of investment in utilities, regardless of form of ownership. There are ample instances of public investment in publicly owned infrastructure, including the massive Federal Interstate Highway System and National Aeronautics and Space Administration; however, most broadband infrastructure deployment is done by private corporations and non-government organizations.

Utilities in California and the United States have a long history of regulation and public investment. A consistent line of policy can be traced from the canal and railroad systems to the electricity grid, through to the interstate highway system and the telephone network, and all the way to cellular telephone and broadband infrastructure. This chapter will begin with a brief examination of the history of public investment in utilities, including infrastructure and subsidized usage, providing historic precedence and context for understanding public investment in broadband infrastructure in the furtherance of public benefit. The American Recovery and Reinvestment Act (ARRA) and the California Advanced Services Fund (CASF) are two such efforts, both having been created and implemented in the past 10 years for the express purpose of broadband deployment and adoption, providing examples of the effectiveness and return on investment from the use of public funds to specifically assist in broadband infrastructure deployment and service adoption.

Federal Programs

Horse and carriage was the primary means for moving goods over land in the early 1800s, and boats and ships were the primary methods of long-haul travel. Boats primarily used rivers and coastal waters for the transport of goods and people, but the construction of canals by the government connected new, inland areas as well, and allowed for faster transport of goods than was previously possible. The Erie Canal was one of the first and, to this day, remains among the most famous canals constructed for this purpose.

The canal was the brainchild of Dewitt Clinton, who initially sought federal funds for the construction. While the federal government declined to build or fund the project, construction began in 1817 after the New York State legislature finally agreed to provide $7 million to build the canal. Construction was completed, and usage commenced in 1825, and the initial investment was recouped within 9 years (New York State Canal Corporation, 2016). In operation until 1882, the canal generated over $121 million in revenue, providing an early example of public investment in “utility infrastructure” for public benefit (USHistory.Org, 2018).

Along with the canal system, the early to mid-1800s saw the rise of the railroad system in the United States. Public investment in railroads came early and was vital to the deployment of the railroad’s infrastructure. As the first “common carrier” railroad, the Baltimore & Ohio Railroad (B&O Railroad) is an excellent example of early government involvement and investment in railroad infrastructure. Devised by Baltimore, Maryland merchants and bankers to compete for trade with the Erie Canal (Wooddy, 1829) , the B&O was launched by the Maryland General Assembly in 1826 (Maryland State Archives, 2015) with the issuance $3 million in stock for its construction (of which it retained a large share), and created a board of commissioners (B&O Railroad, 1841). The investment quickly paid of and spurred economic growth – as late as 1954 the line was generating nearly $3 million a year in profit and transporting millions of dollars of goods to and from Baltimore (Stover, 1995). The success of the B&O contributed to the creation of the Pennsylvania Railroad when the city of Philadelphia, in a drive for economic prosperity and in response to the failure of the state to create a canal system, created the Pennsylvania Railroad in 1846 (Salvato, 2006).

With the support of local and state governments, the local railroad network quickly grew. Local rail systems became interconnected, making rail an easy and inexpensive way to move goods from one market to another. Government investment was vital to the successful construction of the railway system, and the economic benefits generated those systems far exceeded the costs and were accrued to the population as a whole. Seeing the economic prosperity created by the local rail networks, work began on the first “Transcontinental Railroad” in 1863, with the goal of connecting the East and the West coasts. Three different private companies constructed different segments of the line. The route was constructed with federal land grants, financed by a combination of private, state, and federal funding (Pacific Railroad Act, 1862). When completed, the tracks formed a single railroad line connecting the east coast rail networks to San Francisco bay area.

As the railroad system was being built to transport people and goods, the telegraph system was being built to transmit information – the U.S. House of Representatives went so far as to join the two subjects by creating the Select Committee on the Pacific Railroad and Telegraph. Samuel Morse is generally credited with being the inventor of the telegraph, however, prior to his work a rudimentary telegraph system was employed in France, and back in the Unites States another 62 individuals staked a claim as the system’s inventor (Elon University, 2016). Part of what set Morse apart from these other inventors (in addition to his development of Morse Code) was his recognition of an important similarity between the telegraph and the Erie Canal, the B&O Railroad, and the Transcontinental Railroad; the government’s involvement, particularly in funding, would be crucial to successful deployment of the system. In 1843, with $30,000 in financial backing from Congress, Morse built a telegraph system connecting Washington, D.C. to Baltimore (Anderson, 2005). This is the first example in the United States of government funding the deployment of a high-speed, electronic, telecommunications network. The system was slow to develop, and while Congress did agree to provide $8,000 to continue funding the Baltimore operations, Morse was unsuccessful in his attempts to persuade Congress to fund additional deployment. Undaunted, Morse gradually added more lines to his “network,” including the privately financed construction of a line to New York.

Like the Erie Canal and the B&O Railroad, other companies saw the potential of the telegraph and developed multiple regional networks. By the 1950s the number and reach of the networks had grown considerably and the power and potential of the telegraph was undeniable. In 1856 the House Select Committee on the Pacific Railroad and Telegraph issued a report calling for the telegraph system (and the railroad) to link the eastern and western United States.

> The necessity that now exists for constructing lines of railroad and telegraphic communication between the Atlantic and Pacific coasts of this continent is no longer a question for argument; it is conceded by every one [sic]. In order to maintain our present position on the Pacific, we must have some more speedy and direct means of intercourse than is at present afforded by the route through the possessions of a foreign power (U.S., 1856).

In 1860 Congress passed the Pacific Telegraph Act in 1860, which included the appropriation of funding to connect the west coast to the east coast. The Treasury Department was responsible for selecting the bidder, and when other companies eliminated themselves, Western Union was selected to construct the line. Simultaneously, Western Union merged with the existing telegraph companies in California and became the Overland Telegraph Company (Dillow, 2010).

Deployment spread quickly from there. Western Union grew dramatically, from a valuation of $10 million in 1864 to $21 million the following year. By 1866, the company's network had expanded to approximately 100,000 miles of wire, with the growth driving its stock value to more than $40 million (Anderson, 2005). While there was no competition for the first transcontinental build, that changed quickly.

Like the creation of the B&O Railroad to compete with the Erie Canal, other companies in other areas saw the power and potential of the telegraph and began to build their own systems. But Western Union was the dominant corporation and their success and growth lead to the passage of the Mann-Elkins Act of 1910. The Mann-Elkins Act of 1910 granted the Interstate Commerce Commission regulatory oversight of wireline and wireless interstate telegraph, telephone, and cable companies (Dixon, 1910). The Communications Act of 1934 gave regulatory authority over the telegraph industry to a newly created entity, the Federal Communications Commission (FCC) (Anderson, 2005).

The end of the 19th and beginning of the 20th centuries also saw the birth of electricity and the electric transmission grid. Electricity has been intertwined with government since Thomas Edison first obtained permission from New York city officials to build his Pearl Street Power Station and associated distribution system (wires buried underground) (Institute for Energy Research, 2014). Power plants, transmission lines, and electricity rates are all regulated by local, state, and federal governments, and have been since their infancy (Brown and Sedano, 2004). In addition to regulatory oversight, government has long invested in the electricity industry as well.

The Rural Electrification Act of 1936 is the clearest and largest example of public funding for private electric infrastructure (the justification for the investment was the significant public benefit). The Act created the Rural Electrification Administration and empowered an Administrator to implement the Act. Signed into law in May of 1936 by President Franklin Roosevelt, the act appropriated $50,000,000 for the first year of the program (July 1, 1936-June 30, 1937) and $40,000,000 per year for the next 8 years (Rural Electrification Act, 1936).

The Act itself provided that the REA Administrator:

> …is authorized and empowered, from the sums hereinbefore authorized, to make loans to persons, corporations, States, Territories, and subdivisions and agencies thereof, municipalities, peoples utility districts and cooperative nonprofit, or limited-dividend associations organized under the laws of any State or Territory of the United States, for the purpose of financing the construction and operation of generating plants, electric transmission and distribution lines or systems for the furnishing of electric energy to persons in rural areas who are not receiving central station service…(Rural Electrification Act, 1936)

Beyond the construction of generating facilities and transmission lines, the Act also allowed for, "…loans for the purpose of financing the wiring of the premises of persons in rural areas and the acquisition and installation of electrical and plumbing appliances and equipment." (Rural Electrification Act, 1936) In other words, the Act didn't just help with "access" (as defined in Section 2 of this paper), it also helped individual households with "adoption."

The act has been continually amended through the years. The two amendments most relevant occurred in 1949 and 2014. In 1949, President Harry Truman signed House Resolution 2960 which expanded the Rural Electrification program to include the deployment of rural telephone infrastructure. In his signing message, President Truman cited the stagnation of the deployment of telephone services to rural areas, and the success of the REA in pushing electricity into those same areas as his reasoning for signing the Act:

> The importance of this new act is apparent from the fact that today only about 40 percent of our farms have any kind of telephone service at all. This is scarcely any improvement over 1920, when about 39 percent of them had telephone service. The rural telephone service trend is in striking contrast with the progress of electric light and power service in rural areas. In 1935, the year prior to the enactment of the Rural Electrification Act, only about 11 percent of our farms had electricity. Today almost 80 percent are electrified. Most of this gain has been due to the stimulus of the REA program. In the past year, REA-financed systems have been responsible for about three-fourths of all new farm electric service extensions. The success of the rural electrification program is a happy augury of what we may expect from this rural telephone program based on the same principles (Truman. 1949).

More recently, President Obama expanded the REA again in 2014, this time for the purposes of rural broadband deployment (Agricultural Act of 2014). Broadband infrastructure was already receiving government funding to ensure rapid and ubiquitous deployment prior to this amendment; in 2009, under the American Recovery and Reinvestment Act, $7.2 billion was appropriated for the purpose of expanding broadband deployment and increasing adoption. The Act directed the U.S. Department of Agriculture's Rural Utilities Service (RUS) and the U.S. Department of Commerce's National Telecommunications Information Administration (NTIA) to expand broadband access to unserved and underserved communities across the United States. The purpose of the Act was to create jobs, spur investments in technology and infrastructure, and provide long-term economic benefits. The result was the funding of the RUS Broadband Initiatives Program (BIP) and the NTIA Broadband Technology Opportunities Program

(BTOP). BIP makes loans and grants for broadband infrastructure projects in rural areas (USDA, 2015). BTOP provided grants to fund broadband infrastructure, public computer centers and sustainable broadband adoption projects. Of the $7.2 billion, $4.7 billion was allotted to the NTIA to award grants. The remaining $2.5 billion went to the U.S. Department of Agriculture to make loans and grants to companies building out broadband infrastructure in rural areas (American Recovery and Reinvestment Act, 2009).

In 2014, the FCC issued an order to significantly change and update its Universal Service Fund (USF) and Intercarrier Compensation (ICC) programs. The order changes the USF to the Connect America Fund (CAF). The fund's goal, similar to the Rural Electrification Act, is to accelerate broadband infrastructure deployment in rural areas by providing funding to offset the higher costs of deployment in those areas. Per the FCC, "Consumers everywhere – both urban and rural – will benefit. Reform will not only drive economic growth in rural America, but will expand the online marketplace nationwide, creating jobs and businesses opportunities across the country." (FCC, 2014). This statement is recognition by the FCC that public investment in private utility infrastructure, broadband infrastructure in particular, yields economic benefits greater than the amount of the subsidy. They also acknowledge, both in this ruling's rhetoric and in a decision in April of 2016, that broadband access is a necessity for modern life. The 2016 ruling redefined broadband as a Title II common carrier service, thereby changing it from an information service to a telecommunications service and giving the FCC regulatory authority over broadband and broadband providers (FCC, 2016)

California Specific Programs

Multiple recent programs in California also involved state government funding, subsidizing, or investing in private utility infrastructure. In 2006, the Legislature worked with the California Public Utilities Commission (CPUC) and then Governor Arnold Schwarzenegger to create the California Solar Initiative. The multibillion dollar program, administered by the CPUC, provided significant subsidies to incent home-owners to install solar panels on residential roof tops (California Solar Initiative, 2006). The purpose of the program was twofold. First, the state was in the process of shifting California away from dirtier, fossil fuel based, central-station power generation facilities. Second, the state saw the program as an economic development tool to help foster a competitive solar manufacturing and installation industry (Assembly Committee on Utilities and Commerce, 2006).

Following the California Solar Initiative, Governor Schwarzenegger signed into law Assembly Bill 811 in 2008. The legislation authorized local governments to offer low interest loans to residents for the purpose of financing the installation of certain types of distributed, renewable energy generation or making energy efficiency improvements to real property. The state found that the loans to private citizens furthered the state interest by accelerating the deployment of solar energy and energy efficiency upgrades. As with the California Solar Initiative, the upgrades made through the AB 811 program also offset the need for electricity generated from central station power plants in furtherance of a state interest (California Law, 2008).

Private water utilities are regulated by the CPUC and have also received public funds for infrastructure deployment. From the recent water bonds in Proposition 1 to the desalinization plant in Carlsbad, CA, to the retail water provider for the City of San Jose, investor owned, CPUC regulated, private, for-profit water companies have received billions of dollars of public funding for infrastructure construction and repair (CalWatchdog, 2015).

When considering policies and programs to provide funding for broadband infrastructure and adoption, the most specific and directly relevant comparison is with telephone corporations. Telephone corporations of various sizes have received millions of dollars in subsidies through the California High Cost A and B Funds (CHCF-A and CHCF-B) administered by the CPUC. First established in 1987, the CHCF-A was created to keep rural, voice telephone rates comparable to urban rates. Because there are fewer ratepayers and the relatively high cost to deploy the infrastructure necessary to access and provide service to the rural areas, the rates of rural telephone service would be considerably higher than urban rates without subsidization. The CHCF-A achieves this by providing subsidies to "small independent telephone corporations in amounts sufficient to meet the revenue requirements established by the commission through rate-of-return regulation in furtherance of the state's universal service commitment to the continued affordability and widespread availability of safe, reliable, high-quality communications services in rural areas of the state."(CPUC, 2018a) In practical terms, the state collects a small amount of money, funded by a surcharge on all telecommunications end users in California, and distributes that to certain, specific, eligible rural phone companies (CPUC, 2018a).

The CHCF-B fund is similar to the CHCF-A, as it is used to offset the higher cost of providing service in rural areas. The B Fund differs in that it provides the subsidies to larger corporations, known as "carriers of last resort (COLRs)." At the time of the CHCF-A's creation, those corporations were "Pacific Bell Telephone Company dba AT&T California, Verizon California Inc., Citizens Telecommunications Company of California dba Frontier Communications of California, and Cox Communications." (CPUC, 2018a). As the main topic of this paper is the economic impacts of public funding for broadband deployment and adoption, it is important to note that the CHCF-A and CHCF-B programs were recently changed to allow for the monies to be spent on "all reasonable investments necessary to provide for the delivery of high-quality voice communication services **and the deployment of broadband-capable facilities**…" (CPUC, 2018a).

California Advanced Services Fund (CASF)

However, there are limitations to the CHCF-A and CHCF-B programs, as they were originally created to provide subsidies for voice telephone service, and to voice telephony companies only. The programs are limited strictly to telephone companies known as Incumbent Local Exchange Carriers (ILECs), and the funds were for the deployment of infrastructure in their existing service areas.[3] As such, the Legislature and the CPUC worked together to create the California Advanced Services Fund (CASF) in 2008. CASF was created specifically to offset the higher costs of broadband infrastructure deployment in unserved and underserved rural areas. While the goals of CHCF and CASF were the same – ensuring access to the latest communication technology for all Californians – the CHCFs were created to ensure universal telephone service, whereas the CASF was created to ensure all Californians had access to high-speed broadband. Like CHCF, funding for CASF comes from a monthly, on-bill surcharge paid by customers, collected by telecommunications companies, and remitted to the CPUC (CPUC, 2017).

Despite the similarities between CASF and CHCF A & B, there are some key differences. While the CHCF funding is limited to ILECs, CASF funding is available to all companies deploying broadband infrastructure in rural unserved and underserved areas in the state. Unlike the CHCF programs, CASF funding is technology-neutral and can therefore be used for wireless, wireline, cable, or fiber-based communications connection technologies (CPUC, 2008).

[3] Despite the transition to digital communications and away from landline telephony, the CHCF-A and CHCF-B programs continue as of the time of writing of this paper. For more information on the programs see the summary fact sheets on the CPUC web site.

The CASF program was created as a method for funding broadband infrastructure deployment in rural areas. Through several expansions of the program in the 10 years since it was created that focus has been on rural deployment has been retained. However, those expansions have also allowed for several other small uses that contribute to the goal of closing the Digital Divide. In a 2013 reauthorization of CASF, Assembly Bill 1299 by then Assemblymember Steve Bradford created the Public Housing Account within CASF. Since AB 1299 became law on January 1, 2014, 86 public housing infrastructure grants approved affecting 5,678 residential housing units have been approved. The legislation also created a statutory for CASF to extend broadband access to no less than 98% of California households by the end of 2015. As of 2017, the program allowed for funds to be extended in the form of:

(1) Grants and loans for deployment of broadband infrastructure in unserved and underserved areas;

(2) Grants to regional consortia to advance broadband deployment, access and adoption;

(3) Grants to public housing for access and/or adoption activities (CPUC, 2017.)

Through the end of 2015, CASF has collected $255.6 million in surcharges and made expenditures of $137.6 million (CPUC, 2017). According to the latest CASF report from the CPUC, released in April 2016 and covering the period from the program's inception through December 31, 2015, funding has been awarded for 52 CASF infrastructure projects, 27 of these have been completed. When fully built, the 52 projects are expected to connect 301,574 unserved and underserved households to broadband infrastructure. According to data provided in the 2015 CASF annual report, California is getting close to achieving the overall goal of 98 percent broadband deployment. However, when looking only at rural California, which is the primary focus of the CASF infrastructure deployment grants and loans, only about 43 percent of households meet the CPUC definition of having broadband access.

In a 2013 reauthorization of CASF, Assembly Bill 1299 by then Assemblymember Steve Bradford created the Public Housing Account within CASF. Since AB 1299 became law on January 1, 2014, there have been 86 public housing infrastructure grants approved, affecting 5,678 individual residential housing units. The legislation also created a statutory for CASF to extend broadband access to no less than 98% of California households by the end of 2015.

While the majority of this section focused on public investment in private utility infrastructure, with the data in section 1 showing that more than 25% of Californians lack meaningful internet access due to issues other than access to utility infrastructure (network access), it is important to separately and specifically look at government investment in programs related to utility "adoption". Numerous programs, both in California and at the federal level, offer precedent for the government to subsidize "adoption" related behaviors. Both California and the federal government have Electric Vehicle rebates and tax credits to incentivize and subsidize the purchase of electric vehicles. These are adoption programs – they are designed to lower the cost to obtain an Electric Vehicle, and thereby encourage people to "adopt" the technology. The California Solar Initiative, discussed above, was both an infrastructure and adoption program. In this case, the rebates provided an incentive for home owners to invest in residential solar PV infrastructure and "adopt" the technology.

While the Electric Vehicle and solar incentives aren't targeted at specific demographic groups or income levels, other programs are specifically designed to make utility services more affordable to lower income households. The Rural Electrification Act discussed above provided funding to offset the oftenprohibitive costs to retrofit a home with internal electrical wiring. Without such adoption funding, the government's investment in transmission lines and power generation would be rendered moot. More recently, California has created programs to lower the cost of utility services for low income customers. The California Alternative Rates for Energy (CARE) programs provide a 30-35% discount on electricity bills and a 20% discount on gas bills for low income residents. For families whose income is too high for CARE, but still need assistance, there is the Family Electric Rate Assistance Program (FERA) providing a 12% rate discount (CPUC, 2018b). The Energy Savings Assistance Program (ESAP) provides funding for attic insulation, energy efficient refrigerators, energy efficient furnaces, weather-stripping, caulking, low-flow showerheads, and water heater blankets for customers who qualify for the CARE program (CPUC, 2018c).

Telephone service, considered the forerunner to broadband service, is similarly subsidized for low income households to help attain the state and federal governments' goal of "Universal Telephone Service". Under the "Lifeline" program, qualifying individuals receive $12.65/month from California LifeLine and $9.25/month from the Federal LifeLine programs to offset the cost of telephone service (CPUC, 2017b).[4]

When compared to electric and telephone service, broadband is still in its infancy. Broadband adoption programs are more complicated as the costs to connect are higher and the technology barriers more difficult. Still, there is very recent precedent for the effectiveness of adoption related programs in broadband. The NTIA Broadband Technology Opportunities Program (BTOP), funded through ARRA, provided over $100 million for "sustainable broadband adoption" in California.[5] In 2008, the broadband adoption rate in California stood at 55%. By 2009, it climbed to 62%, and today, meaningful adoption rate is 69% (87% including smart phones) (Berkeley IGS, 2017).

California also has precedent for using public funds for broadband adoption programs. Statutory changes in CASF reauthorization legislation allowed a small portion of the funds to go to adoption related activities. Specifically, a Public Housing account was created which allows for the use of CASF funds for access and adoption in public housing complexes and units. Regional Broadband Consortia receive funding from CASF and are allowed to use a portion of those funds for adoption related efforts in their regions. Through the end of 2015, Consortia have used CASF dollars for 19 adoption projects, and to provide digital literacy training in public housing locations affecting 3,152 residents.

The above discussion makes it clear: the thread of government funding of private infrastructure weaves its way through the history of the United States, from the canal systems of the early 1800s to the high-speed, fiber optic communications networks of 2018. There are analogous, and in some cases direct, examples of public funding of broadband infrastructure and adoption. Like broadband, previous investments in utility infrastructure developed networks that convey goods, people, energy, voice-calls, and information from one place to another; be they wires to transmit messages and electricity, or canals and tracks to connect cities and transport goods and people. Volumes have been written detailing different aspects of funding and regulation of each particular utility and type of infrastructure, including infrastructure not discussed here such as airports, maritime shipping facilities, and even NASA's launching of private satellites.

[4] A federal broadband lifeline program was created by the FCC in 2016 under President Obama. In early 2018, the new presidential administration and new commissioners began the process of repealing the program.

[5] For more information on these grants see http://www2.ntia.doc.gov/california

The federal and state programs discussed in this section provide a clear historic precedent for public investment in private utility deployment and adoption. The broadband related access and adoption efforts, however, were discussed as policy precedents with no assessment of their economic impact or cost effectiveness. This next section will examine specific broadband funding programs to assess both their economic impact and their cost effectiveness to see if such investments can be justified economically in addition to being in the public benefit.

4. UNDERSTANDING THE ECONOMIC BENEFITS OF BROADBAND

Understanding of the benefits of Meaningful Internet Access, to both the individuals that receive the access and the public at large, is a critical step in assessing the desirability of policies to promote access and adoption. Unlike the explicit costs required to expand access and adoption, quantifying the many benefits that come with meaningful access to broadband is a demanding and unprecedented exercise, rendering a complete cost-benefit analysis of broadband-promoting policies outside the scope of this paper. However, the two exercises conducted here shed light on the cost-effectiveness of such programs and speak to their desirability. The first such exercise is the development of a taxonomy of the benefits generated by expanding meaningful access to broadband – this is a necessary first step for any attempts to quantify and value these benefits.

The second exercise is a review of the literature that has explored the returns to expanded broadband access. As discussed below, there is a relative dearth of studies providing rigorous quantitative assessments of the individual types of benefits accrued from meaningful access to broadband. As such, a qualitative understanding will have to suffice. However, several studies have made strides in quantifying the returns to broadband access in terms of economic growth at the national and/or regional level. These studies provide a starting point for generating a lower bound on the benefits of the recent CASF projects designed to expand access and adoption to broadband, and in doing so allow for a conservative, albeit rough, assessment of the cost effectiveness of the programs.

A Taxonomy of Broadband's Economic Impacts

Many of the benefits of meaningful access to broadband build upon the benefits of earlier internet technologies. It is clear, though, that those accessing the internet with broadband use the internet both more (Saksena and Whisler, 2003) and in notably different ways than dial up users, accessing more content intensive (Horrigan and Rainie, 2002b; UCLA, 2003) and socially interactive sites than those without broadband (Rappaport, Kridel, and Taylor 2002). In general, it has been found that individuals with broadband access take more advantage of opportunities on the internet than those without broadband (Horrigan and Rainie, 2002b; UCLA, 2003).

How the internet is accessed also impacts a user's ability to reap the possible benefits. The literature traditionally differentiates between fixed and mobile broadband access, with desktop computers, laptop computers, tablets, and smart phones as the technologies under consideration. However, the distinction between mobile and fixed technologies is less important than the functionality of the device. While laptop computers, tablets, and smart phones are all mobile devices, laptops exhibit the functionality of a desktop in a way that smart phones and tablets do not.[6] For our purposes, meaningful access to broadband will

[6] Note that tablets may approach this functionality when combined with the appropriate software and an external keyboard, but remain grouped with smart phones for now. As the technology continues to be developed, this distinction will need to be re-evaluated.

therefore be defined as being able to access the internet at speeds of 6 Mbps/1 Mbps using a laptop or desktop computer. These definitions do, however, differ across studies, and as such, we must be careful to distinguish between the benefits of internet versus the benefits of broadband, and the benefits of broadband in the home above and beyond mobile access to broadband.

When an individual or household receives a broadband connection, benefits occur across three different segments of society. There are the private benefits accrued by the household/individual that adopted, there are external benefits that other entities (e.g. schools, hospitals, utility companies, government agencies, etc.) receive when those entities are able to communicate digitally with a newly connected household, and there are benefits to society as a whole. Additionally, while the thrust of this paper focuses on adoption among individuals and households, in rural unserved and underserved areas, there are similar economic benefits that accrue when business establishments gain access to broadband. This discussion will be organized along those lines, with the private benefits to businesses and households being discussed separately from external benefits.

Perhaps the most widely recognized benefits of broadband for individual households deals with *employment and labor market outcomes and educational opportunities.* Expanded use of broadband technology is frequently claimed to expand employment opportunities for those who gain access (Prieger 2015). On the external margin, access to the Internet in general, and broadband in particular, is important for the job search process because vacancy postings and the application processes are increasingly being moved online. Smith (2010), for example, finds evidence that African Americans and Latino Americans are more likely than others to view lack of broadband access as a 'major disadvantage' in getting good employment opportunities, suggesting that improving access to broadband would disproportionately impact groups that are historically disadvantaged in the labor market. Similarly, access to broadband enables telecommuting and working from home (Qiang, Rossotto, and Kimura, 2009). This certainly relaxes the geographic restrictions that might otherwise be inherent to the job search process, allowing businesses and potential employees to be matched regardless of physical locations. On the internal margin, for those with jobs that require commuting to the workplace, the possibility of telecommuting reduces the travel costs and other transaction costs associated with commuting to work.

A benefit closely related to employment opportunities is the impact on human capital accumulation that comes from increased access to broadband. While discussed in the literature (Prieger 2015), there is no empirical evidence quantifying these impacts. Rappaport, Kridel, and Taylor (2002) find that internet users with broadband use more content intensive sites than those without it, which is suggestive that human capital improvements may follow from improved broadband access. For adults, these channels include improved access to formal continuing education opportunities, informal educational opportunities arriving from improved access to information, and the enhanced digital and computer literacy that comes with repeated use. For children as well, internet access is becoming required to fully participate with elementary school education, and improved access to content rich applications can benefit their education.

The literature has also discussed *healthcare benefits* associated with increased access to broadband. Smith (2010) finds evidence that African Americans and Latino Americans are more likely to view lack of broadband access as a 'major disadvantage' in finding quality health care. Similarly, Cotten and Gupta (2004) find evidence of a positive correlation between internet use for health information and both happiness and health outcomes. While rigorous quantification of these benefits is unavailable, these studies suggest that the use of broadband technology to find health related information, to locate healthcare providers, and to interact with them is a valuable service to households.

Expanded access to *government programs, services, and information* – such as accessing the DMV website at night to make an appointment, renewing a driver's license or car registration, or changing an address – is another oft-cited benefit that households receive from improved broadband access. As with employment and health care opportunities, Smith (2010) finds that African Americans and Latino Americans are more likely to view lack of broadband access as a 'major disadvantage' in accessing government services. Qiang, Rossotto, and Kimura (2009) further note that improved access to broadband is positively related with participation in political processes and grassroots organization. In this sense, access to broadband contributes to both the access of government programs and services and to a more politically active and participatory constituency.

Gaining meaningful access to broadband further benefits households by *expanding the set of goods and services* available to them and by *reducing transaction costs* of acquiring otherwise available products. Many recreation opportunities, such as gaming and the streaming of movie and audio content, require not only internet access but high-speed connections. Rappaport, Kridel, and Taylor (2002) find that internet users with broadband use more socially interactive sites than those without broadband access, indicating that broadband access fosters the use of social media as well.

For individual businesses, access to broadband has significant benefits. While the value to any particular firm will depend in part upon how actively and intensively that firm incorporates IT services in their business practices (Forman, Goldfarb, and Greenstein, 2005), most businesses garner competitive advantages from having access to broadband. For example, Zilber, Schneir, and Diwa (2005) find that 80% of the British Columbia businesses responding to their survey feel they would be competitively disadvantaged without broadband, which offers improvements over narrowband technologies by providing *better security*, an overall *reduction in transaction costs*, the possibility of using *enhanced multimedia applications*, and the *development of complementary products* (Qiang, Rossotto, and Kimura 2009). Reduced transaction costs come through lowering search costs associated with the hiring process, any reduction in overhead costs associated with a telecommuting workforce, and the reduced costs of communication within the firm. For example, in an industry sponsored report on the benefits of broadband, Entner (2008) finds that the US healthcare industry was able to save $6.9 billion in 2005 by reducing internal transaction costs.

Further, broadband improves both *business-to-business* and *business-to-consumer access and communication*. Internet access expands a firm's set of potential suppliers and partners, as well as providing access to potential markets where they do not have a physical presence. Broadband offers further *productivity gains* by generating access to a greater pool of human resources and increasing the productivity of workers engaged in internet intensive tasks (Qiang, Rossotto, and Kimura 2009). Perhaps more importantly, the enhanced integration of business and scientific communities occurs as advanced research and development is shared and communicated using broadband technologies, spurning innovation and research and development in products and processes within the firm (Van Welsum and Vickery, 2007).

When households or businesses receive a new broadband connection, they are not the only ones that benefit – a number of externalities are associated with others in society when new households and businesses come on line or upgrade to broadband. There are *network externalities* associated with each new member to online communities, as the opportunities for social and business interactions grows for all previously existing members of that community. The enhanced social interaction associated with meaningful internet access has been discussed as a force for *building social capital* (Prieger, 2015). Indeed, Dutta-Bergman (2005) found that better access to the Internet in communities is positively correlated with increased community participation, suggesting that social networks and social capital benefit from enhanced internet connectivity. High levels of social capital benefit community members other than those who directly engage in the social interactions that help to create that capital. Other positive externalities include the benefits to society from a better educated population (assuming the connected get human capital benefits), the positive externalities from more participation in the government, such as the improved integration of immigrant populations (Prieger, 2015), and the benefits to society from any new innovation and technological advance that may arise from increased connectivity within and between formal and informal research institutions.

It is reasonable to ask if the benefits discussed above could be achieved with the slower speeds provided by dial-up-internet access. Many of the benefits discussed above can be claimed of dial-up-internet access and other slower forms of internet connectivity and are not necessarily unique to broadband connections. However, to varying degrees, meaningful internet access uniquely provides these benefits for at least two reasons. First, as internet speeds evolve, the applications evolve with them, requiring increasingly fast connections and rendering narrowband access obsolete. In many areas, one requires a broadband connection to functionally interact with the internet and garner the benefits discussed above. Second, faster connections reduce transaction costs regardless of whether or not the same functionality can be achieved using slower internet access. These include the transaction costs associated with gathering and verifying information. To the degree that the reduced transaction costs associated with faster and less costly internet access lead to increased use, then meaningful access to broadband offers benefits above and beyond those of slower connections.

Quantifying the Benefits of Broadband

Despite widespread recognition of the benefits from meaningful internet access described above, there is a relatively small body of literature attempting to rigorously quantify and value those benefits. There are, however, several studies that have undertaken serious attempts at identifying the impact of broadband deployment on economic activity, as measured by economic growth and changes in the labor market. These estimates are advantageous in that, in some sense, they capture the net effect of broadband deployment on the economy. However, they are incomplete valuations of the returns to broadband access because any benefits not mediated by a market transaction are not included. In this sense, these impact estimates can be taken as lower bound estimates of the benefits of increased broadband deployment.

In 2009, Qiang, Rossotto, and Kimura assessed the relationship between GDP growth and the broadband penetration rate, measured as the percentage of the population having a fixed broadband subscription, using a cross-section of average growth rates and subscription rates for countries over the period 1980-2006. They find that increasing broadband penetration by 10% is correlated with a 1.21 percentage point increase in the average growth rate of developed country economies over that time period. These impacts are higher for broadband than their estimates of the impact of narrowband internet and mobile technology penetration, suggesting that broadband has relatively large gains compared to other more recent advances in communication technologies. This makes intuitive sense due to the superior functionality of broadband enabled computers in comparison to broadband enabled mobile devices, or computers connected via dial-up.

Kolko (2012) finds causal evidence that expanding access to broadband providers, from zero providers to 1-3 providers, positively impacted employment growth and establishment growth in the US by 6% and

5%, respectively, over the seven-year period from 1999 to 2006. These impacts were higher for less densely populated areas and for industries more reliant on IT services in their business processes.

More recently, Castaldo, Fiorini, and Maggi (2018) estimate the impact of increased broadband penetration on GDP per capita for a panel of OECD countries over the period 1996-2012. They find that a 1% increase in the broadband penetration rate led to short run (1 year) and long run (2-5 years) impacts on GDP per capita from between $391-$1,474 and $1,682-$4,192 (measured in 2005 US dollars) over the time period, respectively. These results build upon those of Roller and Waverman (2001) which found that one third of per capita GDP growth between 1970 and 1990 was attributable to telecommunications infrastructure investments, showing that the returns to increasing broadband use are not fully realized in the short run.

Cost Benefit Analysis for California Investments

With slightly fewer than 5% of California households still lacking network access to broadband infrastructure (CPUC, 2017a), and just over 25% of Californian households having access but lacking adoption[7], estimating the impacts of CASF efforts so far is an informative exercise for judging future policy proposals. Castaldo, Fiorini, and Maggi (2018) provide estimates of the impact of increases in broadband adoption on GDP per capita, and this is a useful, albeit imperfect, starting point for generating a rough estimate of the recent efforts to expand broadband access in California. According to the US Bureau of Economic Analysis, California had an estimated population of 39.1 million in 2015 and the state GDP per-capita was approximately $63,388 (in 2015 US dollars).[8] Assuming that the coefficients estimated for the US can reasonably be applied to California, and translating into 2015 US dollars, the Castaldo, Fiorini, and Maggi (2016) estimates suggest that a 1% increase in broadband adoption would lead to a short term impact of $475 to $1,789 in California's GDP per capita. How then, do the costs of recent CASF efforts to expand access and adoption[9] compare?

In the most recent Annual Report of CASF, $124.1 million had been spent providing access to 301,574 households over the lifetime of the program. The US Census Bureau estimates that California had approximately 12.7 million households in 2015[10], implying that the CASF funds used to expand access to broadband affected 2.37% of Californian households. A further $2.1 million had been spent providing adoption grants that affected 5,678 units, and another $0.6 million on training 3,152 residents in digital skills and literacy. These programs reached 0.04% and 0.02% of Californian households, respectively.

Funding for adoption related programs through CASF grants has been statutorily limited in both size and scope throughout the history of the program, as such there is limited data to conduct these calculations. However, the latest reauthorization of CASF (contained in AB 1665 passed in the 2017 Legislative session), established a specific "Broadband Adoption Account" for the purpose of funding activities related to "digital literacy training, public education, and outreach programs to increase

[7] Derived by taking the average broadband adoption rate from the last 6 years of the annual broadband survey, and applying it to data provided on page 35 of the CPUC's 2017 CASF annual report.

[8] For more information see: https://www.bea.gov/regional/bearfacts/pdf.cfm?fips=06000&areatype=STATE&geotype=3

[9] Funding for adoption related programs through CASF grants has been statutorily limited in both size and scope throughout the history of the program. The latest reauthorization of CASF (contained in AB 1665 passed in the 2017 Legislative session) established a specific "Broadband Adoption Account" for the purpose of funding activities related to "digital literacy training, public education, and outreach programs to increase broadband adoption by consumers" (California Law, 2017). Further, the legislation appropriated $20 million to the account for those purposes.

[10] For more information see: http://www.census.gov/quickfacts/table/PST045215/06

broadband adoption by consumers" (California Law, 2017). Further, the legislation appropriated $20 million to the account for those purposes.

At a cost of approximately $412 per household affected, the expansion of broadband infrastructure to provide access was substantially more expensive per effected household than either the adoption program ($374 per household) or the training program ($177 per household). Scaling up the latter two programs to reach 1% of Californian households, the adoption program would cost approximately $1.2 per capita to increase broadband adoption rate by 1 percentage point, whereas the digital skills and literacy program would cost a mere $0.62 per capita. Compared to the lower bound estimate of the $475 growth in GDP per capita, the costs of these programs are a pittance and the programs have extremely high benefit to cost ratios.

What about the CASF efforts to expand access? If 42% of those households who gained access to broadband infrastructure adopted broadband in the home, then the program would have increased the broadband penetration rate by 1 percentage point. At this adoption rate the program would have cost approximately $3.17 per capita and garnered $475 in increased GDP per capita, again passing a cost-benefit test with ease. If the adoption rate among these households is higher the benefits would be even larger. In fact, even if the adoption rate falls to zero, introducing the expansion program on top of the efforts to increase access would result in total costs of $4.37 per capita to gain a 1 percentage point increase in the broadband penetration rate, and the benefits would still far outweigh the costs.

This approach to estimating the impacts of expanding broadband adoption in California is a rough and imperfect approach. As one of the world's largest economies, California's GDP is at home among the OECD countries analyzed by Castaldo, Fiorini, and Maggi (2018). A brief sensitivity analysis shows that the smallest estimate of the impact of a 1 percentage point increase in the broadband adoption rate was found to be in Hungary, where GDP per capita increased by an estimated $86.6. Thus, even for the countries seeing the smallest impacts from expanded broadband adoption the benefits to economic growth are of magnitudes higher than the costs associated with the CASF program.

Arguments for and against broadband policy stem from one of two tacks – arguments based upon issues of economic efficiency, and then arguments based upon economic inequalities. While the above discussion has focused primarily upon the former, arguing that the numerous benefits far outweigh the associated costs, from a policy perspective the issues of economic inequality are likely just as important, if not more so. Two features of inequality in meaningful access to broadband, as captured by the concept of the Digital Divide, are of principle importance for policies aimed towards eliminating that divide.

First, as emphasized by Van Dijk (2006), the inequality represented by the Digital Divide is relative – it is not an absolute concept, with a gap between those with and without access. Individuals have a degree of access, depending upon the technology used and the ability to use it. For example, smartphones can achieve minimum standard speeds over both Wi-Fi and cellular networks providing a level of functionality great than no access at all. But, as we saw from the Pew data, those who only have access via smartphones still suffer many of the same hardships as those with no connectivity. Furthermore, the Digital Divide is dynamic, allowing inequalities to grow over time – early adopters for the last technology are likely the earliest adopters for the newest, even while some portions of the population are still catching up with older tech. Thus, the digital divide reaches across generations of technology and the concept is not static.

Second, the Digital Divide interacts with other economic inequalities in important ways, and there are causal relationships in both directions in the Digital Divide – economic inequality nexus. For example, some groups of society lack meaningful access to broadband due to existing inequalities in other domains, such as education and/or income achievement. Income inequality restricts the ability of households to achieve meaningful access to broadband, as evidenced by the results of the Field Poll. Similarly, as the taxonomy discussed above lays bare, lacking meaningful access to broadband limits individuals' abilities to take advantage in the economic opportunities, educational opportunities, and government programs and services offered by society. In this sense, the Digital Divide leads to economic inequalities in other domains. Alleviating or exacerbating inequality in one dimension may have important implications for other inequalities, including the Digital Divide. Untangling these dynamics between economic attainments and inequalities will be a useful step for developing effective policy.

5. A FRAMEWORK FOR PUBLIC POLICY RECOMMENDATIONS

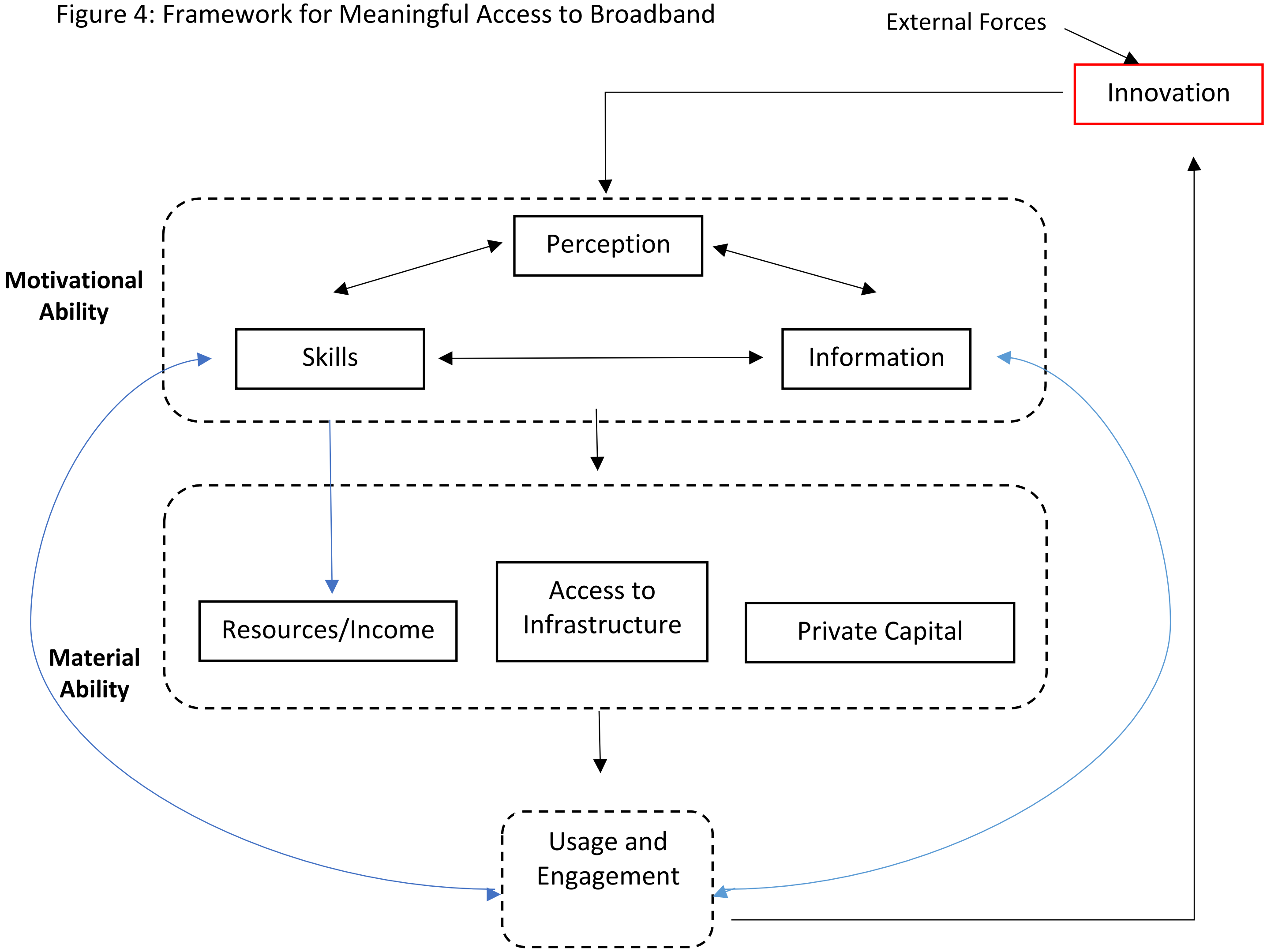
Acquiring benefits from broadband requires achieving meaningful access to the technology. This process is traditionally characterized by a two-stage process – gaining access to the necessary infrastructure and then adopting the technology. Van Dijk (2005, 2006) emphasizes the dynamic nature of this process, developing a model of access that considers the motivational and digital literacy aspects of access to internet technology, both of which are important for determining individuals' relative ability to fully utilize that technology. This expands the traditional definition of access, which is typically used to refer to access to the physical infrastructure necessary to adopt broadband, as it has been here. With a slight change in terminology to restrict the use of the term "access" to its traditional use, we build upon van Dijk's (2005, 2006) model to highlight the dimensions of broadband use relevant to public policy and the relationships between them.

The van Dijk model posits that the motivation to engage a technology is a necessary precursor to any further discussion of access or adoption. Given the necessary motivation, individuals with material access to the technology can then utilize it depending upon their skill-level. Technological advance then begins the process anew. We view the degree of utilization of internet technology as stemming from two main abilities – the motivational ability and the material ability – which jointly determine an individual's engagement with that tech. This variant maintains the cumulative nature of van Dijk's own model where usage is conditional upon material access, which is in turn conditional upon motivational access. A strengthening of motivational access has a positive impact on usage conditional upon degree of material access, and an increase of material access has an impact on usage only to the degree that the necessary motivation exists.

Our extension flushes out the three central components of motivational access: a positive perception of the technology; the knowledge of what the actual benefits may be; and an expectation that the individual would have the skills and abilities necessary to reap those benefits should material access be achieved. A shortcoming in any one of these three areas has the potential to halt any efforts to engage with broadband technology. Furthermore, they are intimately related. Knowledge of the benefits provided by broadband influences appreciation for the technology, and this knowledge is often gained by the application of digital literacy skills. Similarly, a positive outlook on the technology and a desire to engage it leads to the desire to learn more about the technology and acquire the necessary skills to utilize it effectively. Early research on internet adoption found that those who did not adopt internet technology were not doing so because of an explicit disinterest in the technology (Lenhart et al., 2003). More recently, an unexplained adoption gap of 12 percentage points between African Americans and Caucasians indicated a motivation gap between the two groups, highlighting the importance of motivation and its potential contribution to inequalities in broadband adoption (Prieger 2015).

The material ability contains three elements as well: access to any infrastructure necessary to connect to the internet; the household income level necessary to acquire the technology, such as a computer, tablet, or phone; and the income available to subscribe to a service provider. All three of these dimensions of material ability must be achieved for an individual to effectively use the technology. Together, motivational and material ability determine the effective use of the technology. Shortcomings in either one of those dimensions will hamper the acquisition and utilization of the technology and limit the benefits provided. Effective utilization of the technology can contribute to a virtuous cycle through three mechanisms. First, because utilization of internet technology expands access to information, effective usage may increase knowledge of the benefits of the technology, enhancing motivation and leading to increased use. Second, learning-by-doing is central to obtaining digital literacy skills (de Haan and Huysmans 2002; van Dijk 2005). Therefore, usage of the technology increases skill levels, which in turn increases the effectiveness of how the technology is used. Third, digital literacy skills are rewarded in the labor market – any increased digital literacy is expected to have positive returns, which will expand an individual's resource base and the material ability to obtain and use the technology.

Figure 4: Framework for Meaningful Access to Broadband



This model of meaningful internet access highlights the recursive dynamics at play regarding the usage of a given technology, emphasizing that effective usage is endogenous in important ways. In terms of broadband, fully engaging the technology contributes to its evolution and advancement by stimulating demand for the vast array of potential services provided, as well as by actively engaging and contributing to online content. Together with external technological advancements, use of the internet helps to spur innovation in internet technology, beginning the adoption process anew. The evolution of the definition of broadband itself is evidence of the dynamic nature of the tech – dial up connections to the internet are no longer state of the art, and as speeds and access have evolved the applications and platforms have evolved with them, generating the need for broadband and threatening to leave dial up users behind.

The above model provides a holistic look at the determinants of broadband adoption and usage. Although 95% of Californians may have access to broadband infrastructure that meets the statutorily defined minimum speed (CPUC, 2017a), far fewer have actually engaged the technology, indicating that bottlenecks exist in these other areas outside of access to infrastructure. The question of adoption matters because, without it, the potential benefits that the technology has to offer will not be realized. This model provides the conceptual framework for discussing where public policy can affect desired change in the process of broadband adoption and usage, and it is clear that insufficient access to broadband infrastructure is no longer the major cause of Digital Divide. Policy targeting other components of the material and motivational abilities are needed.

From this perspective, we provide a useful segmentation of the population based upon material and motivational access in Figure 5. Public policy can, and will, impact broadband adoption, use, and the benefits that may follow, by impacting the different elements of these two dimensions.

Figure 5: Household Segmentation of Adoption Condition

		Material Access	
		Yes	No
Motivational Access	Yes	*Adopters*	*Wanters*
	No	*Refusers*	*Unconcerned*

We think of motivational access as the willingness to adopt, and is comprised of the following components:

1) a favorable perception and desire to participate in use of the technology;

2) the information necessary to know how to go about adopting it and what the potential uses are, and their benefits;

3) and the expectation that the individual will have the skill set necessary to participate and effectively use the technology should it be adopted.

While it is not necessary to have all three of these to be motivated to adopt, that lack of any one of these factors alone is a sufficient enough impediment that it could prohibit the motivation to adopt. We think of material access as the ability to adopt, which is composed of access to private/personal capital that is necessary to: subscribe to a broadband service, obtain and maintain sufficient personal computing equipment (computing device, modem, wireless router, etc.), and obtain digital literacy training.

From these two dimensions we get four segments of society: those who are both willing and able to adopt broadband technology are our *Adopters*; those willing to adopt but unable due to inadequate infrastructure or resource constraints are the *Wanters*; those with sufficient material resources who lack the motivation or desire to adopt the technology are the *Refusers*; and, lastly, those who lack the resources to adopt the technology but, were they able to, would not adopt anyway are the *Unconcerned* – they face no decision regarding adoption of broadband. Public policy can influence access to broadband by intervening through any of these dimensions. Enhancing material access increases adoption by moving folks in a right to left shift. Enhancing motivational access increases adoption by moving folks in an upward shift. Constructing policy then becomes an exercise in understanding the impediments to making those shifts and finding the most effective means to overcome them.

As discussed in the introductory section of this paper, it is important to consider those who lack Network Access, or access to the necessary infrastructure separately. While Network Access is also Material Access, the root causes are different and will require different policies and programs to remedy the problem. In the context of the diagram above, Material Access is impeded solely by lack of sufficient personal household income. Network Access is independent of personal income level. Those who live in rural areas without network infrastructure are left wanting regardless of ability to pay and shouldn't be considered in the same context as those who have network access but lack the ability to pay the service fee. Thus, there are three clear, overarching impediments to an individual obtaining broadband at home:

1) Lack of Network Access (rural areas without public infrastructure)

2) Lack of Material Access (the inability of an individual to afford service or devices)

3) Lack of Motivational Access

6. POLICY RECOMMENDATIONS

This paper began with a presentation of the hard data, demonstrating a persistent "Digital Divide" in California. It was then argued that the problem rises to the level of government concern, and that the government should find a compelling state interest in closing the Divide. The term meaningful internet access was then introduced to emphasize the importance that policy aimed towards expanding broadband usage must be comprehensive in important ways. Upon that foundation we laid the policy questions to be explored: Is government investment in broadband infrastructure and adoption in the public interest; Does it have historic precedent; Will the investment generate a net positive economic impact for the state? Historical context for the current problem was provided by an examination of the history of public financing of private utility infrastructure and service adoption; both nationally, and in California. This examination found a long and broad history of utilizing public funds to spur deployment and adoption of utilities in their early stages of development. While looking at the history of similar programs can be instructive for developing and implementing current policies, new policies and programs themselves must be rational, and justified under present policy conditions. The inferential, rough cost-benefit analysis undertaken clearly shows multiple economic benefits to ubiquitous broadband adoption.

From the outset of the paper, and more specifically in this section, the option for government to take no action does exist as an option. However, it is clear, the Digital Divide is not closing and won't without additional interventions or innovations. Further, it is clear that inaction will exacerbate negative outcomes in regard to education, employment, and civic engagement. Because of the negative consequences of inaction, the option is rejected.

Having rejected the possibility of taking no action, and having described the conditions of the problem, placed them in historic context, and shown both public and private benefit to solving the problem, this chapter moves to a discussion of the following concrete policy recommendations for closing the Digital Divide:

1) Invest public funds in deployment and adoption initiatives (including assistance with devices and digital literacy training);

2) Promulgate policies that change laws and regulations to promote sustainable deployment and adoption;

3) Require significant public benefits as a condition of mergers and acquisitions; and

4) Have other branches of government and community anchor institutions include broadband adoption and digital literacy in the continuum of care and services they can provide.

These policy recommendations are discussed in detail below using the specific contexts of addressing those disconnected rural households who lack network access, as well as urban households who lack material or motivational access, or both. At the root, those are the main impediments to broadband adoption and meaningful internet access. Remove these impediments and all that remains are the "refusers", who comprise only 2.86% of the total Digital Divide (Berkeley IGS, 2017)[11].

A. Public Investment Policies

With meaningful internet access holding at 70% for several years, it is reasonable to infer that competition has driven broadband access and adoption as far as it will go. With the BTOP and BIP funding, along with the CASF funds in the late 2000s, it could even be reasoned that were it not for prior government intervention, competition would have leveled off at a penetration rate of less than 70%. This is particularly true in rural areas where broadband providers did not exist prior to government investment in infrastructure development.

History shows that public investment in private infrastructure provides significant public and individual benefits. When history, economic impact and need considered jointly, it is clear the single most impactful action government can take is to invest capital resources in infrastructure deployment and broadband adoption programs. Such programs should have five key components:

1) Adequate and reliable funding;
2) Narrow and specific focus;

3) Proper administrative and implementing entity;

[11] This number is not specifically obtained through the polling question. Instead, the figure was calculated using several different responses. Specifically, for the poll n=1628. 13% of those respondents (212) had no internet at home. Those 212 respondents were then asked why they didn't have internet at home. 22% of those respondents listed "not interested" as their primary reason for not having it. 212x.22= 47. That number was then divided by n to arrive at the figure of 2.86% of the population who are "refusers".

4) Specific criteria for dispersal of funds; and

5) Oversight to assure compliance and success.

A model for such an investment program already exists. Given the needs and the political and policy constraints involving taxation and alternative options for raising revenue, any new program developed will, by necessity, look very similar to the existing CASF program. For policy makers it is instructive to look not just at the overall goals and broad strokes of the program, but also the details that help constrain and shape the program to maximize cost effectiveness and reduce the chances of wasted expenditures.

Any program to address the Digital Divide must have access to sufficient and reliable funding for its designated purposes. Funding for CASF comes from a surcharge on consumers' telephone bills for intrastate telecommunications services. The surcharge is collected by the telecommunications companies and remitted to the CPUC. The program began with a surcharge of 0.25% of the consumer's monthly phone bill but has been as high as 0.464% and as low as 0.00%. The charge varies based upon the collection rate and the amount the Legislature has authorized for collection in any particular year (CPUC, 2017a). This is an efficient method of collection as it is collected alongside other existing fees and taxes, meaning no new collection apparatus or administrative organization is needed. The funds collected are in amount small enough that they aren't likely to be felt by most consumers, yet collectively are sufficient for the purpose for which they are collected.

Other potential sources of funds, such as grants from philanthropic organizations, general fund revenue, or local/state tax revenue, have enough fiscal, policy or political limitations to make them poor candidates to fund this type of infrastructure and adoption spending. Additionally, new regulatory bodies could be needed to oversee the expenditures, and such a body would likely lack the necessary expertise. Bond funding is another potential source of revenue. However, a revenue bond would be the most likely and practical option, but the rate and amount of revenue collected would be so low as to make the repayment schedule unfeasibly protracted. Additionally, there would be interest payments on bond revenues that are not necessary with the surcharge placed on rate-payer bills.

Beyond funding issues, a successful program should be narrowly enough tailored to focus exclusively on specific broadband issues, while broad enough to cover all relevant aspects of the subject. CASF was created to fund infrastructure deployment in unserved and underserved areas; which were primarily rural (CPUC, 2007). While 37% of Californians living in rural areas lack meaningful internet access, that translates to only 618,719 households (CPUC, 2017a), as the vast majority of California's population lives in urban and suburban areas. The data from both the CPUC's 2015 annual report on CASF (CPUC, 2016) and the 2017 Annual Broadband Adoption Survey (Berkeley IGS, 2017) show that the Digital Divide is not just limited to unserved and underserved rural areas. Figure 6, which also appeared at the beginning of this paper, again shows the Digital Divide by income, with the darker blue indicating full broadband adoption, the teal showing adoption by cell phone only, and the ending percentage, the total of the two. Figure 6 illustrates the degree to which the Digital Divide is a product of income. The lower the household income, the less likely they are to have meaningful internet access.

Figure 6: Broadband Adoption by Annual Household Income

(Berkeley IGS Broadband Adoption Survey - 2017)

To effectively close the Digital Divide in California, a well-constructed policy would need to do two things:

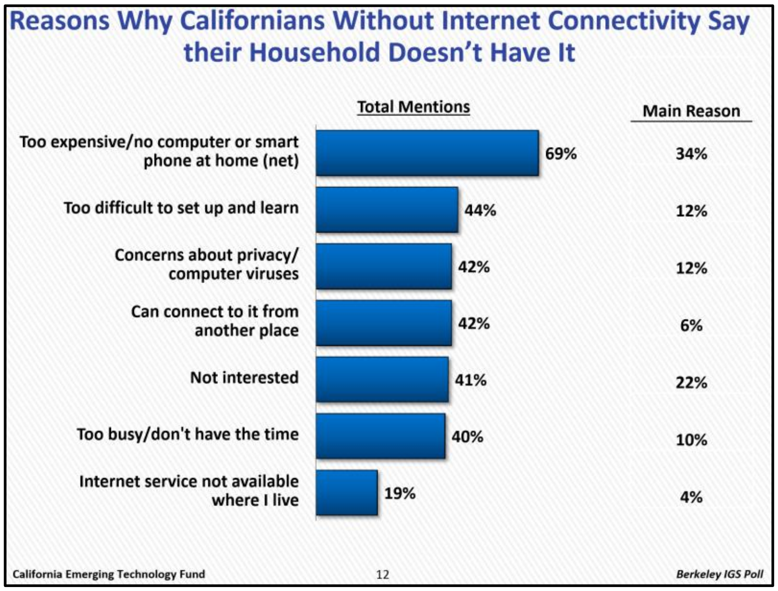
1) Continue subsidizing the increased cost to deploy infrastructure in rural areas, and

2) Fund the several steps necessary to address the low adoption rate in urban areas.

In underserved and unserved areas, simply providing broadband access is often all that is needed to allow people to meaningfully use the internet. In this case, history can serve as an excellent guide. A dedicated pool of revenue would be used to offset the increased cost of infrastructure deployment in less densely populated, rural areas. A program of this type would provide subsidy payments to private corporations to build the connections necessary to provide service to the communities. Which Communities receive broadband access can be selected either by competition or by reverse auction, although a combination of both methods will likely be necessary as, even with subsidies, competition will only go so far in delivering access to the most isolated of rural communities. Additionally, since there will likely be only one provider, it will be necessary to have that provider be regulated until competition arises. In the United States, two companies are generally deemed sufficient to declare a market competitive, while in Europe regulations are usually much stronger. Cave and Hatta (2009) found that differing subsidy policies and strategies result in different outcomes in the tension between deploying new networks and deriving competition on them once they are built. They found competitive pressures were best at driving investment. As a result, they concluded that the best policy is to create a regulatory framework that provides a subsidy but does not impact competition. That is a model that would work for California's rural, unserved and underserved areas. While it appears that CASF attempted to drive competition, whatever program is created to close the rest of the access divide should look to see where CASF was insufficient and seek to provided subsidies that encourage competition in the long run. Without such a subsidy program or a new technology (i.e. some wireless communication system that removes the need to lay miles of fiberoptic cable for the backbone and middle mile), those in rural areas are likely to wait a long time before highspeed Internet access is available to them.

In more urban areas, where access is abundant but adoption lags at 70%, additional measures are needed to provide households with meaningful internet access. Figure 7 shows the main factors cited by those individuals who lack meaningful internet access at home. Sixty nine percent of respondents say it is too expensive and/or they don't have a computer at home. Further, 44% of respondents reported that they do not have broadband access at home because it is too difficult to learn or set up (although not the main or only reason) (Berkeley IGS, 2017). In 2016 74% of the respondents said broadband is too expensive and/or they don't have a computer at home. Further, the way the data was reported that year showed that 59% of the respondents said broadband is too expensive and 42% reported not having a computer at home[12]. The data in 2016 was similar to 2017 showing 43% that they do not have broadband access at home because it is too difficult to learn or set up (Field Poll, 2016). Taken in total, Figure 7 and the data from 2016 reveal the main reasons households lack meaningful internet access are mostly related to cost (of equipment and service) and lack of technical skills, i.e. material and motivational impediments. This clearly indicates policies and programs must be designed that speak to service affordability, computing equipment, and "digital literacy" skills. Providing physical access without addressing the other elements results in building a digital highway to nowhere, and to inefficient and ineffective expenditures of public funds.

Figure 7



(Berkeley IGS Broadband Adoption Survey - 2017)

Adoption Program Design

Such a program did exist, albeit at the federal level. In 2010, as part of ARRA, the Broadband Technology Opportunities Program (BTOP) issued $450 million in grants for, among other purposes, broadband adoption related programs. With 600,000 new low-income household broadband subscriptions in four years (NTIA, 2014) the effectiveness of the ARRA broadband adoption funding provides a good basis for its inclusion in a state policy going forward. And, as Figure 7 and the data from the 2016 and 2017 broadband adoption surveys show, without addressing the adoption gap it is difficult to make progress in closing the Digital Divide. An ideal adoption program will focus on three basic elements (Price, 2013) (ASR Analytics, 2013):

1) Subscription costs;

2) Equipment; and

3) Digital literacy training.

[12] Data was not reported the same way in 2017 so the breakout is not available. There is no reason to think it would be substantially different as all of the data in the survey is consistent year over year.

The connection between these elements and broadband adoption are clearly laid out in the model of broadband adoption illustrated in Figure 4, as they speak directly to the material and motivational impediments to meaningful internet access.

The two primary components of personal material costs are the monthly subscription and the computing device. Most major broadband providers in California have a stand-alone, low-cost broadband offering available to qualified low-income households. AT&T's "Access", Comcast's "Internet Essentials", and offerings from Frontier, Charter, and Cox cover the urban areas of California, with prices generally ranging between about $9.95 and $15 per month. With these providers and low-price offerings, all urban households in California have at least one low-cost broadband offering available to them. But a low price alone may not be enough to spur adoption. First, the economic circumstances of the household may not allow them to afford even the discounted rate. Material access is different for different households and can have varying degrees of strength. Where a discount offering may be affordable to a household making $25,00 per year, that same offering may not be affordable to a household with an income of $15,000. Household expenses such as rent, meeting the more basic needs of children, and other vital household expenditures impact a household's ability to afford broadband. There can also be a perceived lack of material access due to lack of information about the true cost of broadband. A household may have the motivation to adopt, but lack accurate (or any) information about affordable broadband offerings. While having an affordable, stand-alone broadband offering is important in removing material access impediments to adoption, the existence of the rate should be viewed as the lower bound effort, with the recognition that the subscription rate will still be unaffordable to some households, and others may need to be made aware of such offerings.

In addition to the low-cost, stand-alone broadband offers from the providers, in 2016 the FCC attempted to address material access by expanding the federal telephone Lifeline program to include broadband. In 2017, with the change in Presidential administrations, new FCC commissioners were appointed, and the new FCC began to roll back the Lifeline expansion and remove federal subsidies (FCC, 2017) (Larson, 2017). This concern also applies to the affordable offerings above, as many of the offers were mandated as a condition of merger approval and expire after several years. While the rates and subsidies speak to material access, those who are participating are exposed to the technology and gain an understanding of its capabilities. This could potentially improve their level of motivation to adopt and may spur them to maintain a connection even if the rate increases. However, any benefits to motivational access are speculative, and without a program such as Lifeline or discounted rates it is possible the Digital Divide will grow as households lose the subsidies and unsubscribe. As such, states may want to consider creating such assistance programs to work with the discounted offerings to maintain or increase the adoption rate.

An adoption program that focuses exclusively on broadband subscriptions will not significantly close the Digital Divide. Policies and programs must be designed to address other material and motivational impediments. The cost of a computing device, and in some cases a modem and wireless router poses a significant financial (material) impediment to adoption. Entry level computing devices have all the functionality necessary to meet the second part of the definition of meaningful internet access and have been dropping in price for years. However, despite the lower costs, a new device may still be beyond the means of many low-income households. Again, as with the cost of the subscription, factors such as variance in household income, household expenses, and the perceived costs of the device impact material access. Additionally, the perceptions and actual costs of maintenance affect material access. A program that seeks to increase broadband adoption will need to recognize and address the actual and perceived costs of the computing equipment necessary to connect. Some of these needs may be able to be met through existing programs and community organizations that refurbish computing devices and either give them away or sell them at a significant discount. However, the program may have to supplement the supply of devices available if the program is to reach the scale necessary to close the adoption gap.

Digital literacy training is the third component necessary in an adoption program. Providing household with the skills to use a computing device will also likely provide the household with an understanding of what tasks can be accomplished with a computer, and why having one will make their lives easier. As such, that addresses a component of motivational access. But digital literacy skills can also be seen as being impacted by material access. If an individual lacks computing skill, they may incorrectly assume they need to spend money to enroll in a class to gain the skills. There are existing community-based organizations and other entities that have free or low-cost computing classes. A well-designed adoption program will need to increase the number of classes available and make sure those who need the training are informed of the availability of the classes and their costs.

Appropriate State Entity to Administer Program

While the CASF program was administered by the CPUC, it is worth exploring if the CPUC is the appropriate administrative body. When considering the criteria for the administrative entity, it is important to remember the overall policy imperative: closing the Digital Divide as quickly as possible. There are two components of that imperative: 1) closing the Digital Divide, and 2) speed of achievement. While it was addressed earlier, it is worth bringing up in this context as well that the Digital Divide is not a static concept that, once bridged, is eliminated permanently. The Digital Divide has the potential to deepen progressively with each successive generation of technology. The early adopters continue to adopt the newest technology, while the late adopters have yet to adopt technology from a decade ago. As long as the late adopters remain fixed in their position, the early adopters will continue to widen the divide. As such, delays in closing the current divide will be compounded over time. Proper program design and implementation must then take into account both the Divide itself, as well as the urgency necessary in closing, and seek to maximize the number of households assisted in the shortest time possible. To accomplish this, it stands to reason that a program would need to be administered by a body with expertise in the subject matter, and one that has shown the capacity to deliver similar programs.

A government program, by definition, must be housed in some subdivision of government. Two basic options present themselves: 1) place the program administration within an existing body or bodies, or 2) create a new entity for the purpose of administration. To determine which approach is best, these options are evaluated in the context of their ability to most effectively and efficiently achieve the program's goals as stated in the above paragraph. To create a systematic method of determining the appropriate entity for administration, the needs of the program as established by this paper were cross-referenced with the limited number of remotely plausible administrative entities existing in California in 2018. In conducting that evaluation, the following conclusions are reached:

1) The original CASF Legislation gave the program to the CPUC;

2) No other entity in the state is designed to or capable of regulating a utility. Giving it to another agency would be much harder as they would lack the subject matter expertise;

3) The internet is a communication service;

4) The CPUC has historically been the body that regulates utilities, including communications

5) The traditional “poles and wires” authority need not be taken literally as that definition and authority has expanded over time. The internet is the 21st century version of poles and wires.

6) Even though some aspects of broadband are competitive, there are also many aspects that are monopolistic and areas that aren’t competitive. The CPUC has been the state entity charged with regulating monopoly utilities. That experience includes current, low-income assistance programs for California’s private electric utilities.

After conducting the evaluation, looking at the needs of the program and the capacity and capabilities of the potential entities, there is no entity that currently exists in California state government better suited than the CPUC. No other state entity has the expertise, history, and authority as the CPUC. And, while it might possible to create a new entity that is better able to achieve the goals, doing so would face many challenges and cause significant delays in program implementation.

B. Legislative and Regulatory Policies

The investment of public funds will help with infrastructure deployment and adoption in the short term, but without additional interventions the investment alone will not completely close the Divide, nor will it keep it closed. Policy changes are needed to assist in closing the adoption gap and keeping it closed. While no new technology is instantly deployed ubiquitously, policies, such as those in the Digital Infrastructure Video Competition Act (DIVCA) of 2006, have contained specific language to prevent economic discrimination in infrastructure deployment (California Law, 2006). For example, the “cherry picking” language in the DIVCA legislation prevented companies from deploying infrastructure in higher income communities at the expense of low income communities. That language provides a model for ensuring that both infrastructure deployment and sales efforts are equally focused across socioeconomic and demographic groups.

Rate regulation is another tool available to ensure affordability of a service. Historically, rate regulation occurred when corporations were granted monopoly franchises to speed deployment of infrastructure. There are economic and deployment efficiencies gained from this model as the technology reaches more people more quickly (Mody, 1996). With changes in technology and government leading to the decades long trend away from regulated industries, rate regulation in 2018 would draw from historical precedence but face significant barriers in terms of political acceptability (Shelanski, 2007).

Unlike the initial deployment of railroad, electric and telecommunications infrastructure, companies providing broadband are not new companies, but rather fully capitalized corporations providing a new service. Sometimes that new service requires a corporation such as AT&T to upgrade, for example from the old POTS (Plain Old Telephone Service) network of twisted coper wires to a new technology such as a fiberoptic network. Still other companies are able to employ more modest upgrades and utilize existing facilities, such as cellular communications towers. The situation for broadband, then, is not directly analogous to the rush to lay new railroad tracks or telegraph wires to reach new territories. Still, that would not preclude policy makers from considering a different form of rate regulation based upon household income. As was seen above, there is ample precedent for programs designed to offset the cost of utility services. At the federal level, the FCC has offered significant guidance in several ways, not the least of which is the decision to declare broadband a Title 2 Common Carrier – a necessary telecommunications utility. In light of that decision, regulation to ensure broadband is affordable and available to all should be given serious consideration where the market is failing.

As the adoption rate in California has stagnated at approximately 70% for the last six years, an argument could be made that is the maximum reach of competitive market forces. But the lack of adoption, obviously, does not mean a lack of need. State regulatory entities (and Legislative bodies) need to look at the Digital Divide and assess the causes prior to considering regulatory remedies that address the problem. As the data repeatedly cited in this paper indicates a strong correlation between poverty and lack of meaningful internet access, and the same data further shows that affordability is a major concern/impediment to lower-income individuals choosing to sign up for broadband, policies to ensure the affordability of standalone broadband offerings would likely be effective in furthering broadband adoption. As we saw above, similar programs, along with perceived necessity, have driven electricity and telephony adoption rates to near 100%. As seen in the data from the 2017 annual broadband adoption survey, the perceived need for broadband is still lower, particularly among those who don't have broadband. A combination of additional spending on adoption-related programs to raise awareness of the affordability and benefits of broadband discussed in Part A of this section and the assurance of affordable and stable rates provided by income-based rate affordability programs will go a long way to increasing broadband adoption.

One such specific program is "Broadband Lifeline". Progress on Broadband Lifeline is in limbo at the federal level with the current FCC indicating it is going to roll back the progress made by the prior commission. That does not preclude states from recognizing the importance of broadband connectivity and meaningful internet access in the 21st century and implementing a system of their own. A state-level Broadband Lifeline policy in California would follow naturally from the Telephone Lifeline policies the state already employs and recognize the progression of technology. By providing assistance with the monthly service fee, a Broadband Lifeline program would address one of the major identified impediments to broadband adoption. However, policy makers should be mindful that simply expanding Lifeline to include paying for the monthly broadband service would be incomplete. A Broadband Lifeline program would need also to account for device cost, and digital literacy skills – the other two aspects of meaningful internet access – to be successful.

C. Public Benefit Extraction as Condition of Mergers and Acquisitions

Corporate mergers and acquisitions that fall into the jurisdiction of public agencies provide an opportunity to extract public benefit as a condition of the merger. This is a strategy that California has employed successfully in several recent mergers and acquisitions. For example, in the 2005 ruling allowing the respective mergers of AT&T (acquired by SBC), and Verizon (acquiring MCI), the CPUC created the California Emerging Technology Fund for the express purpose of closing the Digital Divide. More recently, Frontier Communications acquired Verizon's "land line" business, and Charter Communications acquired Time Warner Cable. In both cases the CPUC required significant public benefit investment by incorporating numerous Memorandums of Understanding and Settlement Agreements negotiated between Frontier and third party, non-governmental entities into the final order, giving the agreements the force of state law.

Among the numerous conditions in the Frontier decision, those pertaining to broadband access and adoption required Frontier to increase broadband speed in underserved areas and provide service to over 600,000 unserved Californians. The decision also required the installation of public Wi-Fi hotspots in communities that were too remote to reach. To assist with affordable adoption of stand-alone broadband for low income customers, the decision required the purchase and distribution of 50,000 Wi-Fi enabled tablets.[13]

The Charter Decision reflected similar commitments but recognized a difference in both the size of the merger and the composition of the territory. The agreements with Charter have a greater focus on adoption rather than access. To address lack of access, the CPUC required Charter to provide broadband service to 150,000 unserved customers within its territory. The Commission also required Charter to provide free broadband to 75 anchor institutions within its territory. To assist with adoption, like Frontier, Charter was required to provide a low-income, stand-alone broadband offering to qualified households in its territory. It was also required to provide 25,000 wireless hotspots, with at least 50% of those going to communities where English is not the primary language for at least 25% of the residents. Charter also committed to an “aspirational goal” of enrolling 350,000 new households in their low-income program within five years. And finally, they were required to contribute $32.5 million dollars to CETF to further close the Digital Divide.

While it is uncertain how often mergers and acquisitions of this type occur, as can be seen from the combined benefits of the Charter and Frontier decisions, they present an excellent opportunity for regulatory entities to impose appropriate and justified terms as a condition of approval that facilitate expanded meaningful internet access.

D. Institutionalization of Broadband Adoption by Anchor Institutions, Service Providers, CBOs

In addition to governmental entities with direct oversight of the specific industry, many other governmental, quasi-governmental, private, and nonprofit entities have a vested interest in seeing meaningful internet access expanded. As discussed above, the Digital Divide is merely one kind of inequality and is strongly correlated with income inequality. California has numerous programs designed to assist low-income individuals to address inequality – assistance is available for many services including health care, housing, auto-insurance, and most relevantly, electricity and telecommunications services. In each one of those areas, there are benefits to both the entities and customers when the customers have meaningful Internet access.

Given the broad reach of these entities, both in geography and number of individuals served, they have the ability play a key role in the adoption process. Specifically, they can help increase the motivation of their clients and inform them of opportunities that will reduce the cost of material access to broadband. Instead of a siloed approach to service delivery, larger institutions such as health care providers, libraries, schools, utility companies, and state and local government agencies should recognize that meaningful internet access is an enabling technology and not just an end in and of itself, and that greater broadband adoption will benefit both their entity and their customer. This “Institutionalization of Broadband Adoption” strategy is the technological equivalent of taking someone to the emergency room versus getting them health care coverage. Creating a program and/or an internal culture would not be a different mission, but rather one complementary to these institutions’ existing missions. Supporting broadband adoption would likely enable an entity’s customers to better participate in the principal activity of the organization.

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[13] The order, including a complete list of Public Benefit requirements can be found here: http://docs.cpuc.ca.gov/publisheddocs/published/g000/m156/k249/156249641.pdf

Broadband providers in California already offer a stand-alone, low-income broadband product. The challenge is to identify and connect qualified individuals to these offers, and to make sure they have the other components necessary to achieve meaningful internet access, namely a suitable computing device and the skills required to effectively use it. This is where ancillary adoption assistance can help. Entities, in their routine course of business, can provide information that improves individuals' motivation and make them aware of the programs and resources available designed to assist with material access. A program like this can take many forms, being passive or proactive depending upon the institution.

A recent example of this was the project conducted by the Sacramento Municipal Utilities District (SMUD), the California Foundation for Independent Living Centers, and CETF. SMUD is the electricity provider in Sacramento County, and don't own, operate, or offer broadband or communications services. However, as most large institutions do, they maintain a website with extensive information, including a "My Account" section, and have a vested interest in having their customers sign up for online accounts. There is also a benefit to the customer to be able to easily access the information available on the SMUD web site. The site offers information on bill assistance and energy savings programs, allows online payment, and provides information on outages and safety. Although it is not part of their core business, SMUD determined that it made sense to find ways to assist their low-income customers sign up for internet access.

To facilitate these efforts, SMUD sent letters to its Energy Assistance Program Rate (EAPR) customers (See Appendix B), notifying them that as low-income customers they may be eligible for low-cost broadband. The letter provided information about the program, including information designed to raise awareness of existing low-income broadband offerings. Finally, the letter provided the names and contact numbers of trusted, local organizations that could provide more information and assist in the process of signing up. A low-income SMUD customer who called the number reached an individual with specific training in broadband adoption. The person then conducted a "digital triage," asking the caller several questions designed to assess the person's broadband needs and digital literacy skill. Upon completion of the assessment, if appropriate, the caller was provided assistance in signing up for a low-income broadband offering and referred to centers where they could receive free or low-cost computing devices and digital literacy training.

Through this two-year project, completed in June of 2016, SMUD sent out approximately 90,000 letters to its EAPR customers at a cost of approximately $37,500. The letters generated 4,055 calls for a response rate of 4.5%. The 4055 calls generated 1,029 adoptions, for an adoption rate of 25% (CFLIC, 2016). Programs such as this could be implemented by a variety of institutions. Such a strategy could be a stand-alone project, as with SMUD, or it could be an ongoing effort that leverages existing conversations and interactions in a targeted and strategic manner. For example, entities would be able to connect the motivational and material aspects of broadband adoption in a single, one-page pamphlet. To address motivation, the pamphlet would inform the customer of the potential benefits from connecting with the entity digitally. To address material access, it would inform people about low income broadband offerings, free and low-cost computing equipment, and digital literacy training.

There are thousands of large, service delivery institutions interfacing with the public on a daily basis. Whether it be at the customer window of the local Department of Motor Vehicles Office, a hospital or doctor's office, or a school or library, those who interface with customers are in an excellent position to conduct a brief "digital triage" which, in turn, can benefit the customer, the organization, and society as a whole.

7. CONCLUSIONS & FUTURE IMPLICATIONS

The world is modernizing. People may lament that, tilt at proverbial windmills, and long for "simpler times", but modernization and technical advance will continue nonetheless. And it is doing so at a faster and faster pace. While it may seem like the internet has existed forever, the first commercial web sites only began to populate the internet 20 to 30 years ago, with the real growth coinciding with widespread deployment of broadband in the early 2000s. The dial-up capability of the 1990s was not sufficient for facilitating the quantity or speed of data transfers necessary to support eCommerce, telemedicine, education, streaming video, of the thousands of other uses. In 2018, broadband is near ubiquitous (except in rural areas), and it is getting faster. Speed that started in kilobits became megabits, and now gigabits are commonplace when discussing broadband speed. Just as surely as those who first drove the Model T Ford could never have imagined the shape or capabilities of the Tesla Model S or Ferrari F50, it would be incredibly naïve to think gigabit speeds is where broadband ends.

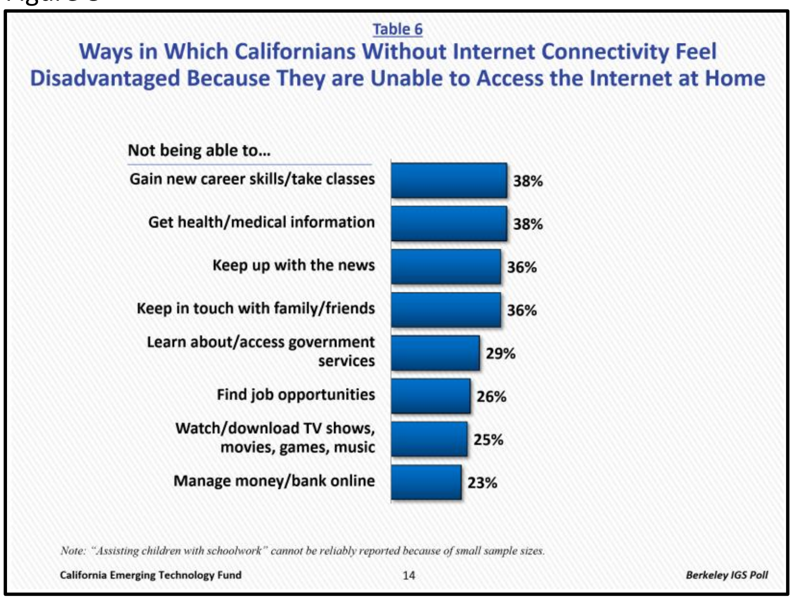
But what about those who don't have access at all? Or those who are limited to a touchscreen on a smartphone with a capped data plan? If you don't have a Ferrari or a Tesla, you can still get to work. The government created and subsidizes mass-transportation in the form of bus and rail systems. But if you lack broadband or a suitable device, or the skills to use it, what then? How does that person compete in today's workforce or high school, and what will they do when the mega turns to giga and the giga to tera?

In California, the Digital Divide has been locked in at about 70% adoption for at least 6 years. Every year that goes by the megas do turn to gigas, applications evolve, and the digitally disconnected fall further and further behind those with meaningful internet access. Computing technology is as essential to successfully navigating civic life in the early 21st century as electricity and telephones were in the early to mid-20th century. However, unlike telecommunications or electricity, using computing technology to accomplish even the most basic of tasks such as searching the Internet, composing, addressing and sending an email, creating and formatting a resume, or filling out an online job application, requires at least minimal level of proficiency, if not fluency, that far exceeds that which was necessary to use a basic telephone.

Obtaining meaningful internet access is a more expensive and less static proposition, for end users, than it was to obtain comparable functionality from the electricity or phone systems. Once a house is wired for electricity, the panel and outlets installed, only minimal and occasional ongoing maintenance is required. Lamps, toasters, and most other electrical appliances can last decades and still function sufficiently. The same is largely true for a phone system, where technical change did little to render obsolete the phone sets found in most houses in the 20th century. While there were some advances as switchboards were replaced by direct calls, push buttons replaced rotary phone, and wireless handsets became popular, the early technology still retained its functionality over the years. Unlike cell phones today, land line phones didn't need to be upgraded every two years (or less). Land-line phones weren't going to get a virus, and, regardless of the devices age, a household's phone provided essentially equal functionality as their neighbors'. Similarly, even the more complicated and relatively recent inventions, such as Call Waiting and Caller ID, were not prohibitively complicated or difficult to learn to use.

How do these technologies compare to those necessary for meaningful internet access? Further, what do we know about the reasons why people don't adopt broadband in the same way they ubiquitously adopted telephone service? Most importantly, type of computing device necessary to achieve meaningful internet access can be expensive as compared to the cost of a telephone – the analogous user interface device. And, they become obsolete much more quickly as well, which adds to both the real and perceived cost for a household to obtain meaningful internet access. Figure 7 above confirms this. Taken from the 2017 Berkeley IGS Poll on broadband adoption and use in California, it shows the number one impediment reported is the lack of a computer of smart phone, and the top three reasons collectively speak to concerns over expense and the necessary skills. Further, it is unclear why individuals say they are "Not Interested", as that could mean many things, but it indicates the importance of motivation and understanding of broadband technology. This data also only asked the question of those without any type of broadband at home, it wasn't asked of those who have internet access through a smart phone. Furthermore, individuals without internet access seem to know they are missing out on something. Figure 8, from the same 2017 Berkeley IGS Poll, shows the way people feel disadvantaged by not having the internet, indicating there is motivation for adoption on the part of many of the disconnected.

Figure 8



(Berkeley IGS, 2017)

Figures 6 and 7 combined show that the biggest impediments to broadband adoption arise from lack of material access. Continuing with the comparative metaphor of the telephone, these are the two key areas where meaningful internet access differs from telephony. Leaving aside the cost of deployment, and focusing solely on the individual household, we see the cost of the necessary device is much more expensive for broadband technology. Similarly, the necessary computing devices are prone to far more frequent technical difficulties and malfunctions than the land-line telephone, becomes obsolete much more quickly, and is much more expensive to replace. While most broadband companies offer an affordable rate for the stand-alone service, the cost of the device itself is an impediment to adoption. Layer on to that the digital literacy skills necessary to operate the device, and many households may simply choose not to spend the limited resources on technology they can't really afford, and don't know how to use. The question of device versus subscription cost would make a good topic for further research, as knowing which the greater impediment to adoption is would help policy makers effectively target the root cause of the problem.

This paper has used the argument that education, the economy, and access to government services and Government Institutions (elected and regulatory bodies), are the primary reasons meaningful Internet access is a public policy concern. It was further argued that the Digital Divide is driving and driven by an economic and educational wedge in society. The data shows that not only does the Digital Divide exist, but that it causes serious problems that can and should be addressed by government. We have asserted that closing the Digital Divide will provide benefits (economic and other) to the individual who receives access, to the state, and to society in general, as shown by the literature on economic growth and broadband adoption. Our rough estimates using data from California indicate that the benefits of recent broadband deployment and adoption programs far outweigh the costs. Further research on the causal impacts of broadband adoption is another important area for future study.

As California has spent CASF and ARRA funds in certain places and not others, it would be possible to conduct a quantitative and qualitative analysis of communities that are geographically isolated, but similarly situated in respect to their demographics and economics. By using economic markers beyond GDP and comparing the communities that have received ARRA and CASF funds to those that haven't, the state would be able to obtain a greater and more accurate understanding of the specific impacts and benefits of broadband adoption.

The primary focus of this paper was to assess the economic impacts of government funded broadband adoption programs, with a specific focus on whether the aggregate benefits of broadband adoption were greater than the costs of the program. As such, there were many aspects of the Digital Divide and barriers to adoption that were left unexamined. In particular, omitted was any kind of detailed look at the specific material access impediments to adoption. It would be helpful to gain a greater understanding of the disconnected population in general that goes beyond the discussion of device cost and service cost discussed above. As government and NGOs look to close the Digital Divide, it would be very useful to conduct polling and focus groups that ask more specific and detailed questions of those households who lack any broadband access at all, those who only have access via smart phone, and those who have just recently adopted. A better understanding of what hardships those populations face due to the lack of access, as well as an understanding of why they lack the access, will facilitate the efforts of policy makers, NGOs, and broadband providers to create programs to overcome the specific issues facing "late adopters."

Changes and improvements in technology will continue to drive demand for new technologies, devices, features, and applications. The commercial web is just 25 years old. Think about what the automobile looked like in 1910, about 25 years after it was invented. Compare that to automobiles of the 1950s and 60s, and the automobiles of today. A driver of a Model T Ford could no more have imagined a Ford Thunderbird, a 57 Chevy, a Ferrari F50 or a Tesla Model S than people today can predict what computing devices and internet technologies will look like in 2050. Think about the evolution of the telephone. Or television. Or even computers; from punch cards and mainframes, to green screens, floppy discs and dot matrix printers, to laptops, and then to smart phones, and tablets. At some unknown point in the future, it will likely become impossible for all but a very small few to survive without internet access in the home. "Smart homes" and the "Internet of Things" are just beginning to emerge, and they will continue to remake the world and the way people engage with it. From education to healthcare and telemedicine, to agricultural technologies and remote water monitoring systems, to employment and access to government, the future is digital. At some point many, if not all of these systems, will depend on people having meaningful internet access at home. By then, the need will likely spur even the most reluctant to adopt technology, and that demand combined with new innovations may make the technology more accessible to people in all income levels.

But what to do until then? While we will always hear the apocryphal tale of the 'remarkable high school student who dazzled everyone with some amazing project completed only on a smartphone that got them into Harvard', the reality is starkly different. Until meaningful internet access becomes ubiquitous, those without access or with limited access will continue to struggle. The data shows they will struggle in school, they will struggle to find work, and they will likely struggle with life in the 21st century. An impartial assessment of the technology and the data clearly shows that, absent a technological innovation or intensive intervention, the Digital Divide and its societal effects will persist. The possibility that there will be some kind technological innovation that is inexpensively, and effectively able to provide access to the internet to all, seems remote. Even if such a technology were to be invented, it would only address a fraction of the problem as the vast majority of Californians who lack internet access at home aren't lacking physical access to the infrastructure. The Digital Divide is much larger in the urban areas where cost – of service and device – and lack of skills, not access, is the impediment.

With relatively stable rates of penetration, government intervention appears the best and most immediate solution to expand meaningful internet access and close the Digital Divide. Historical precedence and economic efficiency arguments support such an intervention. Based upon the data reviewed here, the biggest impediment to meaningful internet adoption is material access, indicating that government policy should focus on this constraint. The vast majority of Californians have physical access to the internet should they choose to adopt, and most Californians who live in urban areas have access to special, stand-alone, low-income broadband offerings from every major broadband provider. The availability of such a product points to three possibilities, which are not mutually exclusive. First, qualifying individuals may not be aware of the affordable offers. Second, household income may be so low that even the low-income offers are unaffordable. And, third, even if the affordability of the service isn't an impediment, that alone may not be enough, as it only addresses one of the three components necessary to achieve meaningful internet access. Whatever the reasons, there exists a gap between access and adoption. Understanding that gap is the key to creating the policies and solutions necessary to permanently close the Digital Divide.

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