ASSESSING THE EFFECTS OF THE INFRASTRUCTURE INVESTMENT AND JOBS ACT ON HIGH-SPEED INTERNET ACCESS, DIGITAL EQUITY, AND COMMUNITY DEVELOPMENT

Opportunities and Challenges of Measuring the Impact of Broadband Policy

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About the Quello Center

The Quello Center, named after the late James H. Quello and Mary B. Quello, is a multi-disciplinary research center within the Department of Media and Information at Michigan State University. The Center stimulates and informs debate on the economic and social implications of media, communication, and information innovations in the digital age. Its network of researchers includes faculty from across the College of Communication Arts and Sciences, Michigan State University, and associates worldwide. The Center's research is focused on the social and economic implications of developments in communication, media, and information technologies, as well as the policy and management issues raised by these developments. The Center often collaborates with other centers of excellence and stakeholders conducting research on issues related the communication and information policy and the social impacts of technology.

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Executive Summary

With the funding authorized by the Infrastructure Investment and Jobs Act of 2021 (IIJA), states and communities have a ten-year window of opportunity to close prevailing digital connectivity gaps, improve digital equity, and harness the power of broadband for individuals and communities. U.S. Congress recognized that the goals of broadband policy cannot be defined once and for all. Digital equity is therefore defined flexibly as "the condition in which individuals and communities have the information technology capacity that is needed for full participation in the society and economy of the United States."

States play a vital role in overcoming the barriers to deployment and adoption and in promoting meaningful uses of advanced telecommunications that advance broader community outcomes. This is an adaptable standard that will change as technologies and uses develop. In addition to broadband access, it will require the availability of appropriate devices, digital skills training, awareness of privacy and security issues, and appropriate uses and applications. Pursuing these goals requires regular reassessment of the technological, economic, and social conditions of broadband availability, affordability, adoption, uses, and their implications.

The current concerted effort to make high-speed Internet services universally available offers a unique opportunity to develop an evidence-based approach to track progress toward the current goals and to evaluate the relative effectiveness of alternative policy models in achieving the desired outcomes. Monitoring is an important tool to track progress to established goals and to assure compliance with statutory and administrative provisions. Evaluation is closely related and assesses the contribution of interventions to outcomes, controlling for additional factors that may be in play and either support or impede goals achievement. Taken together, monitoring and evaluation allow developing a knowledge and learning system that can contribute to better policy.

This report builds on the practice and experience with programs designed to close digital divides. It differs from earlier approaches, such as simpler logic models, by adopting a methodological framework that acknowledges the diversity, dynamic development, and complexities of broadband ecosystems. Building on that earlier work and a long research record, it is a step toward development of a next-generation framework for the required sustained effort. It provides a high-level overview for practitioners and researchers of approaches to broadband policy evaluation, the opportunities opened by IIJA, and the challenges that must be overcome.

Monitoring is an ongoing process that focuses on the progress and performance of a project in real-time to ensure that it is on track to meet envisioned objectives. It is most useful to keep track of direct and instrumental relations, such as how a subsidy is used to serve previously unserved locations or how a digital equity grant is translated to improve digital literacy. States are tasked to monitor sub-awardee progress toward serving unserved locations, changes in digital equity with a specific emphasis on covered populations, and indicators reflecting broader community outcomes. As will discussed in more detail, the IIJA and NTIA have provided a framework of KPIs and specific, measurable, achievable, relevant, and time-bound (SMART) metrics that must be monitored but have allowed eligible entities freedom to adopt additional KPIs. Monitoring and reporting requirements are defined for eligible entities and for sub-awardees, who in turn must report to eligible entities.

Evaluation aims at assessing a project's outcomes and overall impact. Because experience and observations of outcomes will only become available over time, some forms of evaluation will only be possible after program implementation and initial monitoring. It is important to plan for evaluation early on, as this will ensure that the data needed to do it well will be collected as part of monitoring. Evaluation requires a more comprehensive understanding of the factors that affect outcomes and typically relies on causal explanations of the effects of a program. Important areas that will benefit from regular evaluation are the effects of state policies on network infrastructure rollout, the effects of digital equity measures on the state of digital equity, and the joint effects of these programs on broader community outcomes that might also be facilitated by complementary policy initiatives, such as measures to attract start-up companies.

Policies to bridge digital divides will be most effective when the envisioned objectives are aligned with the working of the Internet value system. Likewise, monitoring and evaluation activities needed to support these policy programs require a good understanding of the multitude of relations between infrastructure deployment, digital equity, and broader community outcomes. This requires clarity on how policy interventions interact with economic and contextual factors to influence availability, adoption, uses, and outcomes for individuals, organizations, and communities. Policy implementation often relies on logic models to track the translation of actions into outcomes. Because of the many interdependencies in the broadband system, we augment this approach with a dynamic system model.

The broadband ecosystem model contains three types of factors that must be appropriately modeled in a rigorous policy assessment: policy goals, policy instruments, and contextual factors, such as sociodemographic or geographic conditions that influence the effectiveness of policy. Sometimes it may also be meaningful to identify intermediate goals, such as creating a vibrant broadband supply market or strong broadband demand. Whether all these factors must be taken into account or whether an assessment can be conducted in a simpler way, abstracting from the interdependencies and complexities, depends on the type of question (more narrow and short term questions may pragmatically be addressed in a simplified approach), the time horizon (e.g., the longer the time horizon, the higher the need to consider feedbacks), and the geographic scope (the larger the geography, the more likely the full model is needed).

The impacts of the infrastructure and digital equity programs authorized by the Bipartisan Infrastructure Bill will unfold over several years. Initially, monitoring and first efforts to assessment will focus on deployment and adoption of broadband and on the immediate output and initial outcomes of digital equity programs. Information used in monitoring will be based on sub-awardee progress reports. The direct and indirect contributions of DEA and BEAD programs on digital equity and the uses of broadband raise some additional issues and can be considered a second assessment stage. A third stage of assessment focuses on the broader community impacts of the IIJA. Due to time delays, these effects will only materialize after additional connections are deployed. The time lag will likely vary between types of uses.

Meaningful monitoring and evaluation require establishing a baseline and goals against which changes can be compared. The 56 states and territories invested a tremendous amount of effort into establishing baselines for a wide range of indicators, including the availability of infrastructure, the number and location of unserved and underserved residences and business, and for selected

indicators reflecting the state of digital equity. In most cases, the situation before a program is initiated can be considered a pragmatic initial reference point. It is intuitive, there is evidence documenting it, and even if the available information is incomplete, it provides a starting point and framework to identify which additional information will be needed going forward. In theory, it would also be possible to select an envisioned state as a baseline and then assess the magnitude of a shortfall and develop a path to close it. For BEAD and DEA, the overarching goals and timelines to achieving them are broadly set by statue and the NTIA NOFOs.

Monitoring and evaluation require a comparison standard against which outcomes are compared. Because it has a narrow instrumental focus, monitoring will often be possible using simple before-and-after approach may suffice. Evaluation typically seeks a causal explanation of changes that result from a policy intervention. Appropriate counterfactuals can be the starting point (also called the status quo ante), a past trend, peer groups, or best practice performers. It could also be based on the gap to an envisioned goal.

Monitoring of deployment and adoption of broadband must start as awards were made to sub-awardees. Data on outputs will primarily be drawn from the reports required by the sub-awardees and they will document the situation in project areas. Statutory provisions, requirements in the NTIA NOFOs, and any additional KPIs adopted by the states will be collected. For BEAD, they include metrics derived directly from the sub-awardee reports, such as the number of unserved locations that were connected, information on the technology and quality of the deployed connections (e.g., supported download and upload speeds, latency), and information on low-cost pricing options. Similarly, metrics on the output of programs aiming at increasing digital literacy will have to be collected from grantees.

Monitoring in the digital equity area typically will focus on two aspects. As in the case of infrastructure, it will be important to track the progress of projects funded from DEA appropriations. Metrics will have to be based on the project proposal and the agreed deliverables (e.g., the number of adults trained in digital and cybersecurity skills). There is also a role for the monitoring of other digital equity goals, such as the state-wide level of digital literacy. In the case of digital equity, it will be more difficult to establish a causal link between policy interventions and outcomes, because many other factors are in play. We will return to this question on the next section, which will discuss evaluation.

A wide range of metrics is available that can be used to assess the broader community impacts of broadband. Broader community outcomes will typically materialize with variable time delays. The magnitude of these delays is not well understood. Thus, simple monitoring of indicators and metrics related to broader community outcomes will only be of limited value. Methods of evaluation and empirically more robust research methods will be needed, as will be discussed in more detail below.

Data collection, curation, and sharing are essential, integral components of meaningful program monitoring and evaluation. Because additional data collection is costly, it is important to utilize available data sources where possible and appropriate. However, important areas, such as digital literacy, remain incompletely documented or not documented at all. In this section, we provide an inventory of main datasets and their strengths and limitations. We also develop guidelines for the development of a data management strategy.

The report ends with eight steps that provide a road map for conducting systematic monitoring and evaluation: (1) Documentation of the starting conditions at the beginning of program implementation (the status quo ante). (2) Development of forward-looking plans to monitor key outcome metrics and make sure the data is available. (3) It is important that data generated by awardees and state surveys is made available, as far as possible, in an openly accessible, well documented way with appropriate meta data. (4) Shortly after first outcome observations are available, states should start to create metrics to evaluate how program awards translate into short-term program goal achievement. (5) Once state outcomes data for network deployment become available, it is possible to get an initial understanding of the effectiveness of programs. (6) As time passes, initiatives that may take longer to show effects (digital literacy, broader community outcomes) can be evaluated. (7) Once longitudinal data is available, rigorous statistical evaluations of outcomes are highly recommended. (8) Planning, monitoring, and evaluation information should be integrated into a knowledge and learning system which can inform continuous policy adaptation.

1 Introduction

With the funding authorized by the Infrastructure Investment and Jobs Act of 2021 (IIJA, also known as the Bipartisan Infrastructure Bill), the states and communities have a ten-year window of opportunity to close prevailing digital connectivity gaps, improve digital equity, and harness the power of broadband for individuals and communities. U.S. Congress gave states a vital role in overcoming the barriers to deployment and adoption and in promoting meaningful uses of advanced telecommunications that advance broader community outcomes. Market forces and competition contributed to an extension of the network to locations that allow earning a sustainable business model. However, market forces have been deficient to serve high-cost locations, low-income groups, and otherwise disadvantaged groups remain unserved at an acceptable timeline. The development of workable solutions to close these remaining digital divides and bring broadband to unserved and underserved locations requires familiarity with local and regional conditions. Thus, the IIJA and subsequent implementation measures by the National Telecommunications and Information Administration (NTIA) develop a unified, integrative federal framework that retains latitude for states and territories ("eligible entities") to adopt models that are appropriate to addressing the state- and location-specific barriers.

U.S. Congress also recognized that the goals of broadband policy cannot be defined once and for all. Digital equity is therefore defined flexibly as "the condition in which individuals and communities have the information technology capacity that is needed for full participation in the society and economy of the United States."[1] This is an adaptable standard that will change as technologies and uses develop. In addition to the need to deploy broadband access to all unserved

[1] Sec. 60302(10), Infrastructure Investment and Jobs Act of 2021, Public Law No. 117-58, retrieved September 15, 2024, from https://www.congress.gov/bill/117th-congress/house-bill/3684/text,

locations and improve the quality of service to underserved locations, U.S. Congress recognized several other pillars, including the availability of appropriate devices, digital skills training, awareness of privacy and security issues, appropriate uses and applications, that are needed to advance the envisioned broader community outcomes of broadband connectivity. Sustaining the goal of digital equity therefore implies regular reassessment of the technological, economic, and social conditions of broadband availability, affordability, adoption, uses, and their implications. The current, pragmatic definition of the quality of connectivity that should be available to everyone is a connection with 100 Mbps download and 20 Mbps upload capacity, minimum technical capabilities such as latency at or below 100 milliseconds, and better resilience. Moreover, Congress envisions 1 Gbps connectivity for all Community Anchor Institutions. As they have in the past, these thresholds will continue to develop over time.[2]

The current concerted effort to make high-speed Internet services universally available offers a unique opportunity to develop an evidence-based approach to track progress toward the current goals and to evaluate the relative effectiveness of alternative policy models in achieving the desired outcomes. Monitoring is an important tool to track progress to established goals and to assure compliance with statutory and administrative provisions. Evaluation is closely related and assesses the contribution of interventions to outcomes, controlling for additional factors that may be in play and either support or impede goals achievement. Taken together, this allows developing a knowledge and learning system that can contribute to better policy. Development of such a knowledge and learning system can take advantage of the variations of policy implementations and stakeholder responses across states, independent territories, and Tribal lands. Properly

[2] What is considered "broadband" evolved from 200 Kbps download and upload capacity in 1996 to currently 100/20 Mbps. In its most recent 2024 Section 706 Report, the Federal communications Commission (FCC) embraced a long-term goal of 1 Gbps download capacity and 500 Mbps upload capacity, without establishing a timeline to reach these thresholds. See FCC (2024), para 2.

documented and analyzed, the experiences can be translated into knowledge that can help improve all programs over time. In addition, the scale and diversity of current federal, state, and local policy initiatives demand transparency and accountability to assure the responsible use of public funds.

Past policy efforts also recognized the importance of evaluation. Some programs, especially those adopted in response to crises, such as the Broadband Telecommunications Opportunities Program (BTOP) in 2009 and responses to the Coronavirus pandemic in the early 2020s, had to be implemented quickly. In these cases, evaluation was often an afterthought, conducted after program completion, and primarily motivated to maintain transparency and accountability. The programs authorized in IIJA are different and contain many provisions that guide monitoring and evaluation. Regular monitoring helps track progress to the envisioned outcomes and evaluation of the progress allows systematic learning from the experience that can be used to adjust broadband initiatives. Such a broader vision will achieve four interrelated goals.

First, although the IIJA and complementary programs, such as the Capital Projects Fund and the Rural Digital Opportunities Fund (RDOF), authorized more than $100 billion in resources, managing funds prudently to maximize their reach and impact remains of utmost importance. Second, given that the current initiative is a multi-year program, good monitoring and evaluation will help increase the effectiveness of the broadband policy instruments over time. This can be achieved by using appropriate methods to compare a unit (community, state) against its own past, with peer units, or with best-practice units. Third, because data collection is costly, careful design of monitoring and evaluation is needed to minimize the burden of additional reporting requirements. Fourth, good monitoring and evaluation also is in the interest of good stewardship of public funds and taxpayer money.

If monitoring and evaluation efforts are initiated in parallel with program implementation, they can be designed more effectively so that valuable information is preserved from the beginning. Monitoring programs of the magnitude and scope of the IIJA will require collaboration between practitioners and researchers on the ground in specific communities, at the level of states, and at the national level. It will benefit from a diversity of qualitative and quantitative approaches, including case studies, ethnographic approaches, statistical analyses, and computational approaches.

This report builds on the practice and experience with programs designed to close digital divides. It differs from earlier approaches, such as simpler logic models, by adopting a methodological framework that acknowledges the diversity, dynamic development, and complexities of broadband ecosystems. Building on that earlier work and a long research record, it is a step toward development of a next-generation framework for the required sustained effort. It provides a high-level overview for practitioners and researchers of approaches to broadband policy evaluation, the opportunities opened by IIJA, and the challenges that must be overcome. It will explain how broadband policy interacts with other supply-side, demand-side and contextual factors and how reliable knowledge on the effects of broadband policy can be generated. It explains assessment approaches that range from pragmatic, easy to implement methods with minimal data requirements to more advanced statistical tools. Early during IIJA implementation, more pragmatic approaches are necessary as observations documenting the outcomes of the initiatives are not yet available. Over time, more robust and advanced methods can be used. Done systematically, monitoring and evaluation will document the progress of communities and states relative to their own past, how they perform compared to peers, and how they compare to the most promising practices.

The document is organized as follows. Section two briefly recaps state broadband goals and the roles of monitoring and evaluation in accomplishing them. Section three emphasizes that good monitoring and evaluation would benefit from measurement systems that adopt a comprehensive view of the broadband ecosystem. This will sharpen understanding of the multiple interacting factors that influence its development and the interrelations among them. We will then use this framework as a basis for the discussion of approaches to the monitoring and evaluation of the multiple broadband policy initiatives in section four. Section five provides an inventory of data sources that could be brought to the monitoring and evaluation tasks. It also discusses principles of data curation and management. Section six brings these elements together by integrating the discussion into a practical approach. It also provides a first sketch of promising practices. Section seven offers concluding thoughts.

2 State broadband goals and the importance of monitoring and evaluation

Major policy initiatives typically are initiated when a problem is recognized vividly, and policymakers can find a shared vision for how to address it and which goals to pursue. Effective implementation requires continuous monitoring of progress toward the envisioned goals. Initially, monitoring will focus on the instrumental relations between actions and immediate outputs. This will allow us to identify and overcome possible roadblocks and manage previously unrecognized risks. As experience and data becomes available over time that documents immediate, intermediate and long-term outcomes methods of evaluation will help to assess the effectiveness of actions and again provide an opportunity to adapt interventions going forward. Planning, monitoring, evaluation, and policy adaptation form a learning system that will serve to improve policy and outcomes over time. The IIJA and DEA provide unique opportunities to share experiences and knowledge among communities and states that can further improve outcomes.

2.1 The vision of the Bipartisan Infrastructure Bill

State broadband goals and plans for allocating program funds are structured in line with statutory requirements in the Bipartisan Infrastructure Bill and the additional guidance provided by NTIA for Volumes I and II of BEAD planning and for the state Digital Equity Plans. NTIA established twenty requirements that add specificity to the general statutory goals, covering a wide range of project dimensions, from a reiteration of the overall program goals to procedural aspects such as environmental assessment and guidelines for certain affordability goals. Specifically, goals for infrastructure deployment, digital equity, and a vision for broader community outcomes are formulated. Within that framework, states have some degree of freedom to develop state-specific key performance indicators (KPIs), metrics, and implementation plans. Statutory and state-selected goals then become the yardsticks for implementation. Monitoring and evaluation are important tools to track progress toward achieving these goals.

It is not necessary to list all specific goals here as they are well documented in the state planning reports, but a few high-level comments will be helpful. In line with statutory requirements, every state has adopted 100/20 Mbps as the minimum speed threshold for a location to be considered as served. In addition, states adopted the quality goals established in the Bipartisan Infrastructure Bill, such as less than or equal to 100 millisecond latency and resilience. As prescribed, states envision the overarching goal of the program to connect every currently unserved location. Initially, BEAD envisioned connecting every unserved location with fiber. Rising costs and more accurate estimates of the costs of connecting every unserved location have resulted in a more flexible approach, allowing a mix of fiber and alternative technologies as long as the quality thresholds established in IIJA and the vision of installing reliable technology are met. By modifying the threshold for very high-cost locations states can choose a technology mix (a "cascade of options") that allows all locations to obtain service.[3]

Affordability goals expressed by the states align with the BEAD requirements to develop a Low-Cost Broadband Service Option and Middle-Class plans. Almost every state adopted the BEAD example service option, a $30 or less per month ($75 or less for Tribal lands) subscription option that was envisioned to be eligible for the Affordable Connectivity Program (ACP). With the winding down of ACP on June 1, 2024, and the uncertainty as to whether pending initiatives in U.S. Congress to appropriate additional funding, states may need to pivot to other solutions. Several service providers have announced a continuation of existing and the launch of new low-income pricing

[3] See Evan Feinman, Choosing the right mix of technologies to achieve Internet for All, retrieved on September 14, 2024, from https://www.ntia.gov/blog/2024/choosing-right-mix-technologies-achieve-internet-all, August 26, 2024. Comments on the NTIA draft guidance were due on September 10, 2024.

plans.[4] All this will likely affect state adoption goals, which center around affordability to connect more households and foster the development of digital literacy skills and meaningful uses.

States worked hard to outline plans to operationalize adoption, affordability, and access goals using consistent strategies. For access, states focus on deploying infrastructure to unserved and underserved populations as identified by state broadband data collections in the National Broadband Map maintained by the Federal Communications Commission (FCC).[5] The NTIA proposal guidelines required the states to outline their plans and processes for accepting and reviewing service challenges, identify eligible locations, and deploy funds to sub-grantee bidders. States primarily discuss access as their focal digital equity goal. States may only accept challenges for non-deployment activities, such as digital skills training, if their plan ensures deployments to all unserved and underserved locations with leftover funds. Some states supplement this approach with additional data from the American Community Survey (ACS) and/or their own state-level data collection initiatives to augment network data with socio-economic information.

Adoption is the least-discussed dimension in the BEAD proposal guidance, even though it could be considered an overarching goal of the Bipartisan Infrastructure Bill. States generally define their adoption goals with a focus on the number of households subscribing to Internet access. Some states define adoption more broadly including digital skills/literacy and the establishment of digital navigator programs. Many states also referred to ACP enrollment as a key component of their reported adoption strategy but the end of ACP in June of 2024 requires an adaptation of these

[4] See FACT SHEET: President Biden Highlights Commitments to Customers by Internet Service Providers to Offer Affordable High-Speed Internet Plans, Calls on Congress to Restore Funding for Affordable Connectivity Program, retrieved on September 14, 2024, from https://www.whitehouse.gov/briefing-room/statements-releases/2024/05/31/fact-sheet-president-biden-highlights-commitments-to-customers-by-internet-service-providers-to-offer-affordable-high-speed-internet-plans-calls-on-congress-to-restore-funding-for-affordable-connect/, May 31, 2024.
[5] See FCC National Broadband Map, retrieved on September 15, 2024, from https://broadbandmap.fcc.gov/home.

plans. As the BEAD Program is focused on achieving 100% connectivity, most states discuss adoption as an outcome that cascades from improved access rather than a specific, independent goal.

State proposals vary on the level of detail provided for progress benchmarks. Most states discuss universal connectivity as their goal in the broadest sense, without explicitly defined scaffolding to evaluate progress. A few states offer more detail in their intended timelines and benchmarks. For example, Wyoming aims to increase service to meet BEAD standards by 10% each year starting in 2024 through 2029. However, explicit outlines of these incremental goals were rare in the BEAD planning volumes. States adopted additional, specific goals in the separate Digital Equity Plans that were drafted in response to the Digital Equity Act (DEA) and the NTIA State Digital Equity Planning Grant Notice of Funding Opportunity (NOFO). For example, Requirement 2 of that NOFO mandates the establishment of measurable objectives for documenting and promoting specific digital equity goals among the eight covered populations (see below).

State timelines mirror the required BEAD timeline. For their BEAD applications states were required to provide two volumes of planning documents for BEAD and an action plan summarizing their state's digital equity challenges and priorities. States typically aligned digital equity plans with BEAD timelines. Consequently, most states situate their goals on a five-year timeline, with BEAD funds deployed and infrastructure built and functioning by approximately 2027-2028. Additionally, states were given specific timelines to designate staffing, open the challenge submission window, and publicly report a final list of eligible locations.

2.2 Monitoring and evaluation as tools of broadband planning and implementation

The IIJA, NTIA Notices of Funding Opportunity, and subsequent guidance documents contain numerous reporting requirements that support implementation. They form an initial basis for

monitoring and subsequent evaluation. These two forms of assessment are related but have complementary objectives and uses and employ different methods. Monitoring is an ongoing process that focuses on the progress and performance of a project in real-time to ensure that it is on track to meet envisioned objectives. It is most useful to keep track of direct and instrumental relations, such as how a subsidy is used to serve previously unserved locations or how a digital equity grant is translated to improve digital literacy. States are tasked to monitor sub-awardee progress toward serving unserved locations, changes in digital equity with a specific emphasis on covered populations, and indicators reflecting broader community outcomes. As will discussed in more detail, the IIJA and NTIA have provided a framework of KPIs and specific, measurable, achievable, relevant, and time-bound (SMART) metrics that must be monitored but have allowed eligible entities freedom to adopt additional KPIs. Monitoring and reporting requirements are defined for eligible entities and for sub-awardees, who in turn must report to eligible entities. Important monitoring tools include the regular review of project milestones in meetings with program officers as well as semi-annual and annual reporting requirements. Monitoring also helps to identify risks that might jeopardize project success early on so that corrective measures can be undertaken.

Evaluation aims at assessing a project's outcomes and overall impact. Because experience and observations of outcomes will only become available over time, some forms of evaluation will only be possible after program implementation and initial monitoring. It is important to plan for evaluation early on, as this will ensure that the data needed to do it well will be collected as part of monitoring. Evaluation requires a more comprehensive understanding of the factors that affect outcomes and typically relies on causal explanations of the effects of a program. Important areas that will benefit from regular evaluation are the effects of state policies on network infrastructure rollout, the effects of digital equity measures on the state of digital equity, and the joint effects of

these programs on broader community outcomes that might also be facilitated by complementary policy initiatives, such as measures to attract start-up companies. Evaluation therefore requires a longer time-horizon and more comprehensive analyses of qualitative and quantitative information. Evaluation tools include surveys, interviews, focus groups, case studies, participant observation, document analysis, logic models, and parametric and non-parametric statistical methods. Especially in a long-term program such as those initiated by IIJA, evaluation results will ideally be reflected in appropriate policy responses. If all is well, the course should be sustained. If shortcomings are revealed, an adopted course of action may be modified, or a program may even be terminated and replaced by another one.

3 Selecting an appropriate measurement framework

Policies to bridge digital divides will be most effective when the envisioned objectives are aligned with the working of the Internet value system. Likewise, monitoring and evaluation activities needed to support these policy programs require a good understanding of the multitude of relations between infrastructure deployment, digital equity, and broader community outcomes. This requires clarity on how policy interventions interact with economic and contextual factors to influence availability, adoption, uses, and outcomes for individuals, organizations, and communities.

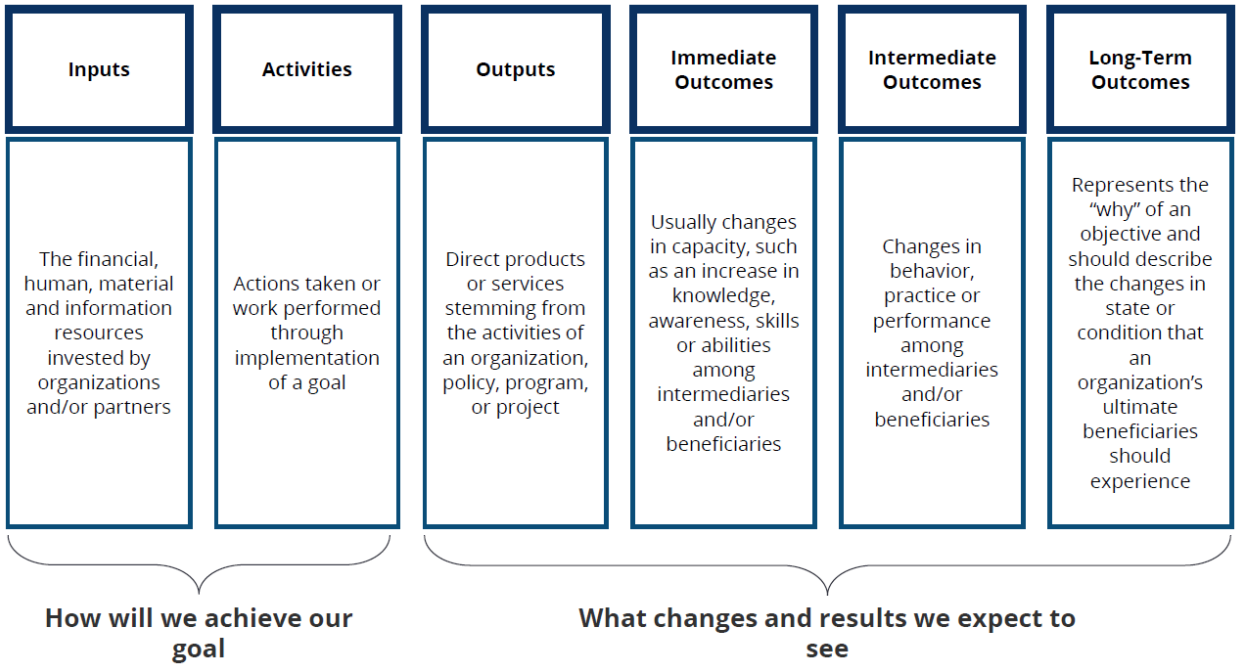

Figure 1: The logic model framework. Logic models break long-term goals into smaller building blocks to provide guidance for decision makers on actions to be undertaken. They also provide simplified scaffolding for monitoring and evaluation. Source: NTIA, 2021, p. 16.

The Internet for All program recognizes this when conceptualizing digital equity, defined by U.S. Congress of achieving parity of digital participation in economic and society, as an outcome of a series of interrelated digital inclusion activities, each building on the former: Affordable, robust

broadband service and Internet-enabled devices that meet user needs enable applications and online content. Together with access to digital literacy training, quality technical support, and measures to ensure online privacy and security they contribute to improving the state of digital equity.[6] This stacked model of broadband and digital equity policy also is embedded in the NTIA logic model that informs its Internet for All activities.

States, communities, foundations and advocacy groups also use logic models to describe how specific policy actions translate into outcomes (e.g., Rhinesmith, Dagg et al., 2023; Rhinesmith, Krongelb et al., 2023). Logic models are an important first step to focus attention on key factors and relationships. They break long-term goals into smaller building blocks to provide guidance for decision makers on actions to be undertaken. As such, they also provide scaffolding for monitoring and evaluation. They typically are action and implementation-oriented and therefore simplify the complexity of relationships and interdependencies that exist in the broadband ecosystem. To make sure that they are reliable and accurate, it is advisable that they are regularly updated with information about the experience with the chosen course of action so that the interventions can be adapted if needed.

One of the limitations of logic models is that they deliberately simplify the process of transforming input and activities (the two blocks on the left of Figure 1) into outputs and short-, medium- and long-term outcomes (the four blocks on the right of Figure 1). Moreover, they do not explicitly take contextual factors and developments that affect the wider Internet system, such as technological developments, into consideration. In reality, high-speed Internet connectivity affects individuals, organizations, and communities in multiple and often unexpected ways. Because of the many

[6] See NTIA, Digital Equity Act Programs, webinar presentation on May 18, 2022, retrieved September 15, 2024 from https://broadbandusa.ntia.doc.gov/sites/default/files/2022-05/DEA-101-Webinar-Presentation-05-18.pdf.

interdependencies between players, the larger Internet value system is often referred to as an ecosystem.

Because of these characteristics of the broadband system, the logic model approach must be augmented with a systemic approach. Figure 2 depicts an alternative approach, modeling broadband as an ecosystem of interrelated actors and processes. This will allow building a generic, generative framework that is robust and informed by the experience with earlier broadband policies and the associated evaluative research. It provides a framework that will allow measuring and assessing the interactions between broadband availability, broadband adoption, uses, and broader community outcomes in a rigorous and reliable manner.

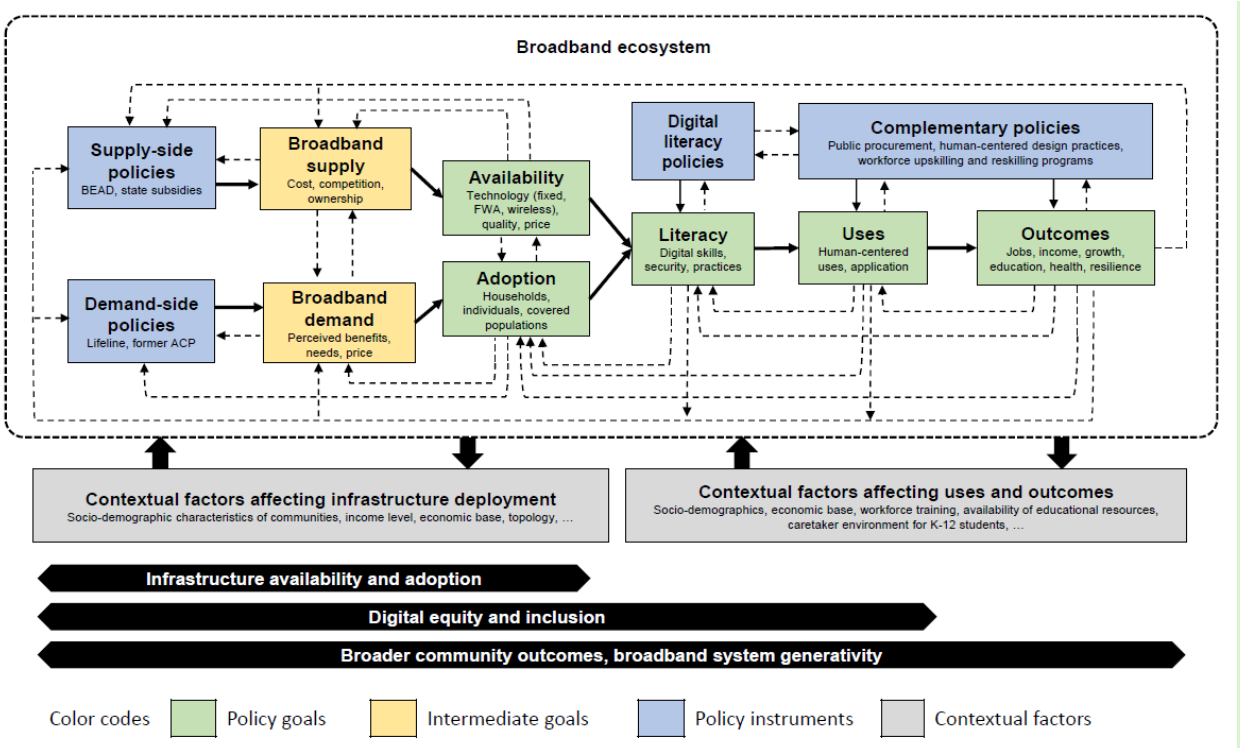

Figure 2: The broadband (eco)system framework. Solid lines stand for direct effects, dotted lines represent interactions and feedback effects that develop over multiple time periods. Pragmatically, they can be neglected in short-term monitoring, but they must be considered in medium-term and long-term evaluations to obtain reliable assessments of the effects of broadband policy.

Figure 2 contains three types of factors that must be appropriately modeled in a rigorous policy assessment: policy goals (shaded in green), policy instruments (shaded in blue), and contextual factors, such as sociodemographic or geographic conditions that influence the effectiveness of policy (shaded in gray). Sometimes it may also be meaningful to identify intermediate goals, such as creating a vibrant broadband supply market or strong broadband demand (shaded in yellow). Whether all these factors must be taken into account or whether an assessment can be conducted in a simpler way, abstracting from the interdependencies and complexities, depends on the type of question (more narrow and short term questions may pragmatically be addressed in a simplified approach), the time horizon (e.g., the longer the time horizon, the higher the need to consider feedbacks), and the geographic scope (the larger the geography, the more likely the full model is needed). The black arrows at the bottom of Figure 2 illustrate the range of factors that need to be included in sound assessment of infrastructure availability and adoption, digital equity and inclusion, and the broader community outcomes.

As the Internet for All program recognizes, utilizing the benefits of Internet access for health care, education, job creation, access to government services, civic participation, and other community outcomes also requires appropriate devices, digital skills including cybersecurity awareness, and human-centered design of applications and services. This is congruent with insights from research on digital divides and how to ameliorate them (e.g., van Dijk, 2020, for a synthesis of the literature). How effectively digital connectivity is translated into desirable outcomes depends on how well these additional factors are aligned with each other and how effectively they work together. This system is also shaped by the multitude of policies, including supply-side, demand-side, digital equity, and complementary policies. Outcomes also depend on the context of a location or a community, such as its economic and community resources, its socio-demographic composition, and locational factors.

The broadband ecosystem model builds on these insights and links them to the knowledge base on the factors that influence digital divides and affect whether they are improving or worsening over time. It depicts the multiple steps that link broadband access, adoption, and uses of broadband with individual and community outcomes. Digital literacy, including awareness of information security risks and practices, amplify this process and the potential benefits from broadband connectivity. Digital connectivity broadens the opportunities to develop new applications, services, and uses. The most important impact of digital connectivity is to enable the capabilities of individuals, organizations and communities to realize their full potential and contribute to human flourishing (e.g., Werbach, 2017).

There are also numerous feedback effects that influence the working of the broadband ecosystem. Positive feedback effects typically develop over time and further deepen the benefits of connectivity. For example, increased digital literacy or the availability of more advanced digital services may increase the demand for higher quality connectivity. In turn, this additional demand may lead to a better supply of services and devices. Similarly, higher community income may contribute to demand for new services and applications. These are desirable synergies, but they need to be safeguarded, as digital technology will amplify both desirable and undesirable effects. For example, communities whose connectivity lags that in other locations or populations may experience relative disadvantages, new forms of exclusion, and decline. Continued monitoring and evaluation are therefore also needed if the goal is to strengthen the forces that amplify desirable, positive effects and avoid undesirable ones.

Experience and research show that the broadband ecosystem does not automatically generate positive and minimize negative effects. It needs appropriate regulation and governance to safeguard the desirable effects of digital connectivity. Over time, numerous federal, state and local efforts can improve the working of the broadband ecosystem. Some, such as high-cost support for

telephone companies, continued and were adapted from earlier programs that were initially developed to support universal access to telephone service. BEAD is making a massive effort to subsidize the supply of network infrastructure and services. Until it expired in May 2024, the Affordable Connectivity Program (ACP) provided demand-side, complementary support for qualifying households to lower the prices for broadband service. BEAD complements older federal programs, such as the Rural Digital Opportunities Fund (RDOF) or the Lifeline program, as well as state and community programs. It is important to avoid conflicts between these multiple initiatives and to assure that they are coordinated to achieve the highest impact (GAO, 2022, 2023). However, currently no comprehensive documentation of all the programs is available.[7]

In addition to supply and demand-side subsidies, states and communities have utilized in the past and plan to utilize as part of IIJA a range of other measures to expand high-speed Internet connectivity. Some measures aim at reducing the cost of investment so that projects become commercially viable for ISPs and new entrepreneurs entering broadband access markets. Granting free or low-cost access to public rights of way or public civil engineering infrastructure or dig once policies that allow the sharing of civil engineering costs between different services all reduce the total cost of investment. Similarly, streamlined permitting processes can help reduce investment costs.

Moreover, states and communities have experimented and often had positive experiences with alternative ownership models. Because cooperatives and municipal enterprises have a broader, public benefit goal they often deploy broadband differently and more equitably than private, commercial enterprises. IIJA and BEAD establish that cooperatives and municipal enterprises should be eligible for awards, but more than a dozen states continue to impose major roadblocks

[7] The FCC Broadband Funding Map, https://www.fcc.gov/economics-analytics/funding-map, provides data for 10 support programs by the FCC, NTIA, RUS, and the US Department of Treasury.

on public ownership.[8] Like the history of private ownership, the empirical record of public ownership reveals examples of success and failure (Whitacre & Gallardo, 2020; Yoo et al., 2022). Public ownership in not a workable solution in all situations and communities must evaluate its advantages and disadvantages carefully.

Local, state and federal policies also influence other parts of the broadband ecosystem in direct and indirect ways although their effects may often be difficult to discern. This includes such diverse areas as K-12 education policy, the availability of libraries and public computer centers, the availability of digital navigators and other continuing education activities, or workforce training opportunities. Some communities are experimenting with innovative models, such as using 4H school programs to provide digital literacy training to adult populations.[9] All these measures can improve the digital literacy of broadband users and increase the effectiveness with which broadband access is translated into broader community outcomes. Of particular importance is whether various initiatives at the community and state level are developed with an integrated and comprehensive vision in mind (see Rhinesmith, Dagg et al., 2023).

Last but not least, contextual factors affect how well policies and entrepreneurial activities can be translated into broader community benefits. Some of these factors, such as the average and median household income in a location, the skills of the local workforce, and the proximity to institutions of higher education, may be difficult to change in the short term, even though they are affected and often improved by digital connectivity. Consequently, broadband policies need to be developed with the unique local advantages and challenges in mind. This need to be sensitive to

[8] Nearly of third of states place legal restrictions on such models or prohibit municipal ownership outright. See Tyler Cooper, Municipal broadband remains roadblocked in 16 states, https://broadbandnow.com/report/municipal-broadband-roadblocks#:~:text=Prediction%3A%20Municipal%20restrictions%20will%20be,undertaken%20by%20the%20U.S.%20government, May 30, 2024 (visited June 19, 2024).
[9] See https://4-h.org/programs/tech-changemakers/ (visited June 26, 2024).

the local diversity of conditions is one of the reasons why the IIJA delegated many implementation issues to states and communities.

Because of these dynamic interactions, measuring the effects of IIJA policies is increasingly difficult further to the right-hand side of Figure 2. More data and better measurement models exist for evaluating the impacts of supply- and demand-side policies as well as ownership models on network investment, network quality, and network performance (e.g., Briglauer et al., 2024). Even there, additional work is needed, as lack of data and incomplete information complicate high-quality assessments. Although there is evidence of the positive contributions of digital literacy training, workforce training, and the range of complementary policies that affect the broadband ecosystem, less is known about their overall effectiveness and the strength of the contribution to broader community outcomes (e.g., Lobo, 2020)

4 Preparatory steps toward state broadband policy assessment

This section describes preparatory steps and early choices that are needed for the development of a systematic approach to monitoring and evaluation. This includes the planning for stages and granularity of assessment, the establishment of a baseline and of goals that should be achieved, a selection of appropriate indicators and metrics, and the selection of appropriate counterfactuals that can be used to assess changes over time.

4.1 Stages and granularity of assessment

The impacts of the infrastructure and digital equity programs authorized by the Bipartisan Infrastructure Bill will unfold over several years. This implies that monitoring and evaluation will also evolve in stages. Moreover, the programs initially focus on specific locations, areas, and populations but their medium-and long-term effects will diffuse more broadly. Initial assessment efforts can pragmatically focus narrowly on supported projects. However, the assessment of broader community outcomes will have to go beyond areas and populations that were the direct beneficiaries of support. In addition to methodological questions, this raises unique challenges related to the consistency and availability of data.

Initially, monitoring and first efforts to assessment will focus on deployment and adoption of broadband and on the immediate output and initial outcomes of digital equity programs. The direct and indirect contributions of DEA and BEAD programs on digital equity and the uses of broadband raise some additional issues and can be considered a second assessment stage. A third stage of assessment focuses on the broader community impacts of the IIJA. Due to time delays, these effects will only materialize after additional connections are deployed. The time lag will likely vary between types of uses.

Investment, digital equity, and broader community outcomes could be narrowly assessed for areas targeted by BEAD and DEA programs. Although this makes sense initially, the IIJA envisions digital equity as a national objective. Consequently, the appropriate granularity for the assessment of broader community outcomes will be municipalities or higher-level census geographies such as counties, an entire state, and the nation. At this level, a rigorous assessment of the effects of better connectivity will be complicated by the many direct, indirect, and feedback effects that shape how differences in the availability of connectivity and the adoption of broadband translate into these broader outcomes. Although a wide range of metrics to assess such broader outcomes is available, some may lack sufficient granularity and/or may not be available over sufficiently extended periods to allow the necessary longitudinal assessment.

4.2 Selection of indicators and metrics

Monitoring and evaluation depend on the availability of appropriate indicators, metrics, and measures.[10] Some of these indicators, metrics, and measures will emerge in the process of evaluation. For example, if a series of focus groups and town hall meetings is envisioned as part of monitoring and evaluation efforts, they will likely generate valuable bottom-up insights. Other indicators and metrics will have to be defined early on, or the information may be lost. During the early stages of program implementation, sub-awardees will be the main source for this information. Later, public data sources may reflect some of the data. However, because project areas are often not congruent with census and other geographies that are used in public statistics, information that is not collected from sub-awardees will likely be lost or only available in proprietary databases that are not accessible for the assessment of program success. Moreover, some data may need to be

[10] An indicator establishes a general concept to be measured, such as the key performance indicators (KPIs) established in state broadband plans. A metric is more operational, a specific unit, method, or measurement protocol to capture an indicator. A measure is a specific measurement of an indicator using a metric (e.g., a latency of 72 milliseconds using a specific measurement protocol).

collected in a collective effort by states and the federal government over time. The earlier such efforts start, the more likely they will contribute to more effective program design.

For these and other reasons, including transparency, accountability, and compliance, relevant statutes and NTIA implementation guidelines define multiple reporting requirements. Moreover, the delegation of many decisions to eligible entities gives them an opportunity to define additional KPIs and SMART metrics that are appropriate for the specific conditions and concerns of a state. Table 1 summarizes important statutory requirements for BEAD. The statutes and NTIA also establish similar requirements for digital equity programs (that eligible entities typically can customize to their needs) (see NTIA, 2023).

Table 1. BEAD statutory reporting requirements (Infrastructure Investment and Jobs Act of 2021, Sec. 60102 (j))

Reporting requirements of the eligible entity to the Assistant Secretary of Commerce	Reporting requirements of sub-awardees to the eligible entity
Initial report (after 90 days) Semi-annual reports that (i) describe how the eligible entity expended the grant funds; (ii) describe each service provided with the grant funds; (iii) describe the number of locations at which broadband service was made available using the grant funds, and the number of those locations at which broadband service was utilized; and (iv) certify that the eligible entity complied with the requirements of this section and with any additional reporting requirements prescribed by the Assistant Secretary. Final report (no later than after one year after all funds were expended) that (i) describes how the eligible entity expended the funds; (ii) describes each service provided with the grant funds; (iii) describes the number of locations at which broadband service was made available using the grant funds, and the number of those locations at which broadband service was utilized;	Semi-annual reports (i) describe each type of project carried out using the subgrant and the duration of the subgrant; (ii) in the case of a broadband infrastructure project-- (I) include a list of addresses or locations that constitute the service locations that will be served by the broadband infrastructure to be constructed; (II) identify whether each address or location described in subclause (I) is residential, commercial, or a community anchor institution; (III) describe the types of facilities that have been constructed and installed; (IV) describe the peak and off-peak actual speeds of the broadband service being offered; (V) describe the maximum advertised speed of the broadband service being offered; (VI) describe the non-promotional prices, including any associated fees, charged for different tiers of broadband service being offered;

(iv) includes each report that the eligible entity received from a subgrantee under paragraph (2); and (v) certifies that the eligible entity complied with the requirements of this section and with any additional reporting requirements prescribed by the Assistant Secretary.	(VII) include any other data that would be required to comply with the data and mapping collection standards of the Commission under section 1.7004 of title 47, Code of Federal Regulations, or any successor regulation, for broadband infrastructure projects; and (VIII) comply with any other reasonable reporting requirements determined by the eligible entity or the Assistant Secretary; and (iii) certify that the information in the report is accurate.

In addition to the requirements listed in Table 1, the statute contains provisions on standardization and coordination of information provision. It entrusts the Assistant Secretary of Commerce and the FCC to "standardize and coordinate reporting of locations at which broadband service was provided using grant funds received under this section in accordance with title VIII of the Communications Act of 1934" and to provide a standardized methodology to recipients of grants and subgrantees for reporting the information described in the statute. Finally, it instructs the eligible entities to collect information on broadband subsidies and low-income plans (Infrastructure Investment and Jobs Act, Sec. 60102 (j)).

These requirements establish an important set of initial KPIs and SMART metrics. Given statutory language, additional guidance from NTIA is to be expected. These reporting requirements focus narrowly on the programs funded by the Bipartisan Infrastructure Bill. They are designed for and most appropriate for the initial stages of monitoring and to assure accountability and transparency of the use of funds. For evaluation purposes additional information is needed. Some of this information is available in other public data sources although it might have to be organized in a user-friendly way. Other information may have to be generated as it is not yet systematically collected. For example, as Figure 2 shows, for some monitoring and evaluation questions, it will be important to have contextual information available. For others, the role of other policy programs will

have to be included in the analysis. Assessments of broader community outcomes will depend on the curation of additional data that is currently not systematically collected. Section five delves deeper into these issues.

4.3 Establishing a baseline and goals

Meaningful monitoring and evaluation require establishing a baseline and goals against which changes can be compared. The 56 states and territories invested a tremendous amount of effort into establishing baselines for a wide range of indicators, including the availability of infrastructure, the number and location of unserved and underserved residences and business, and for selected indicators reflecting the state of digital equity. Between now and the first awards of grants to sub-awardees there is another window of opportunity to refine these baseline indicators if a more complete inventory is desired. In most cases, the situation before a program is initiated can be considered a pragmatic initial reference point. It is intuitive, there is evidence documenting it, and even if the available information is incomplete, it provides a starting point and framework to identify which additional information will be needed going forward. In theory, it would also be possible to select an envisioned state as a baseline and then assess the magnitude of a shortfall and develop a path to close it. For BEAD and DEA, the overarching goals and timelines to achieving them are broadly set by statue and the NTIA NOFOs.

All programs require a focus on the target areas (unserved and underserved locations) and populations (specifically the eight covered populations) and give the states some freedom to select indicators against with to measure performance. Project areas will likely contain served and unserved locations and a mix of technologies that are used to provide connectivity. Thus, the baseline for the share of unserved locations in an area will range from between zero (all locations served) and one (no location served). States have created similar metrics for other indicators, or

they can generate them going forward. However, it would be limiting to only examine the initial focal areas and groups, as the ambition of the Bipartisan Infrastructure Bill is to enable digital equity across all areas and populations. Moreover, activities targeted to unserved locations and covered populations also have direct and indirect effects on other areas and populations. Thus, a monitoring and evaluation framework that examines both outcomes for target areas and groups and the effects of BEAD and DEA more broadly seems to be most appropriate.

Initially, data on project performance submitted by sub-awardees will have to be used to monitor progress. As locations are being connected, these numbers will eventually also show in already existing data sources, albeit with delay. For example, the number of households with a fixed broadband connection in a census block or tract can be obtained from the national broadband map data published by the FCC every six months. In other cases, such as the monitoring of digital equity, data from award recipients will also be useful initially. This may allow insights into the number of adults that participated in digital skills training, possibly measures of the skills they obtained, and results from follow-up surveys. However, such information will remain project-specific as there is only limited systematic information available that documents digital skills, let alone digital equity. Hence, new data collection efforts will be needed (see the next section below).

Table 2 summarizes key metrics that help establish a baseline and for which goals can be established. It also includes metrics that capture initial indicators of developments in an area that would have happened without the policy intervention. Monitoring will then track the progress of the project, based on the starting point, relative to the trend, or relative to the envisioned goal. A baseline assessment will also benefit from a clear understanding of the resource basis available to address the identified problems. This will include federal allocations to the states, state funds that may be available, and may include other resources such as private foundation support.

Table 2. Selected initial baseline metrics

Indicator	Example metrics
• Availability of broadband	• Number/share of connections supporting various download and upload speeds (e.g., 25/3, 100/20, 940/500) • Availability of different connection technologies • Number/share of unserved locations in an area (project area, census tract, county) as of a specific date • Number/share of underserved locations in an area as of a specific date • Average number of connections added per year during the past three years • Average change in availability over past three years
• Access to devices	• Population with access to a desktop or laptop computer • Population with access to a smartphone • Population with WiFi at home • Population with special needs that has access to appropriate devices
• Price and affordability of broadband	• Prices of 25/3, 100/20, 940/500 Mbps fixed broadband • Price of mobile broadband connections • Availability and price of low-cost affordability plan • Middle class affordability plan constructed. This plan should include specific metrics and data sources for evaluating progress • Cost of additional connections.
• Reliability and resilience of broadband	Network latency • Network outages • Customer complaints
• Adoption of broadband	• Share of population with access to service but no subscription • Share of covered populations with access but no subscription • Average change in adoption over past three years
• Status of digital literacy	• Average digital literacy and skills • Digital literacy and skills for covered populations • Average change in digital skills over past three years
• Available resources to address the performance gaps	• BEAD funding per unserved location • Total state and federal funding per unserved location • Philanthropic and private sector funding • Gaps in funding identified to achieve 100% connectivity • Staffing, possibly for each component of IIJA goals (e.g., availability, digital skills)
• Telecommunications workforce readiness	• Number of telecommunications workers hired • Number of telecommunications workers with certain certifications
• Sustainability beyond BEAD and DEA	• Sources of funding identified for continued staffing after project end date

4.4 Selecting appropriate comparisons (counterfactuals)

Monitoring and evaluation require a comparison standard against which outcomes are compared. Because it has a narrow instrumental focus, monitoring will often be possible using simple before-and-after approach may suffice. Evaluation typically seeks a causal explanation of changes that result from a policy intervention. Appropriate counterfactuals can be the starting point (also called the status quo ante), a past trend, peer groups, or best practice performers. It could also be based on the gap to an envisioned goal.

In a basic before-and-after approach, all changes following a policy initiative are attributed to the intervention. This simplifies the analysis, but it also has known, and potentially serious, shortcomings. It only yields an accurate picture if broadband access would not have changed at all without the policy intervention. In most situations, this is not the case as other factors are in play that affect broadband availability. Innovative technologies become available, entrepreneurs develop new business models, and consumer willingness to pay evolves. Therefore, a before-and-after method will most likely over-estimate the true effect of the policy intervention.[11]

Several other approaches are available that avoid these disadvantages. They differ in how they establish a more defensible baseline. One option is to assume that past trends in the geography of interest (e.g., as state, a county, a census tract) would have continued unabated. For example, assume that two percent of unconnected households were connected on average during the past five years. Then the forward-looking baseline would assume that only households in excess of two percent can be attributed to the policy intervention. The advantage of this approach is that past numbers are typically known, and the average annual change can be calculated easily. However, if the incremental costs of adding households increased as the network expands to more rural areas,

[11] This is not always the case. In rare situations, for example in the presence of strong headwinds that would have worsened broadband access, the method could underestimate the effects of a policy intervention.

the past trend will overestimate what would have happened in the absence of the policy intervention. Consequently, the method will underestimate the effect of policy.

A second option is to compare a geography, such as a state or a county, with others that did not benefit from a comparable policy intervention (did not receive the "treatment"). Rather than using the past trend in the location of interest, this approach uses an average across non-treated locations as a baseline. This is the framework of difference-in-differences (DiD) analyses which compares units that experienced a policy intervention with units that did not experience a change. The difference between the two types of geographies, properly adjusted for other factors that may have been in play, is attributed to the policy intervention. DiD analysis is methodologically compelling, but it may be difficult to find appropriate, comparable units that have not benefitted from a policy intervention, given that BEAD is a national program. Galperin and Bar (2024) have used this method to assess the effects of the Affordable Connectivity Program (ACP). Their study also faced the challenge of finding locations that could serve as a comparison group. Another option for statistically rigorous analysis is a regression discontinuity design (RDD). This method measures the effects of an intervention above and below a threshold level (e.g., Campbell, 2023, chapter 2).

Benchmarking the geography of interest against other units is a third option. In a simple approach this could be locations that are considered comparable because they faced similar starting points and overall conditions (e.g., comparable household income, population density and dispersion). A variant of this approach is to apply statistical benchmarking techniques. These methods use parametric or non-parametric statistical techniques to compare a geography of interest with others. This method systematically considers variations in the conditions and allows to assess the effectiveness of a policy measure in a geography relative to other geographies. A challenge is to statistically control all relevant conditions that affect the outcomes. The method can be used in

numerous circumstances to develop a deep understanding of the overall effectiveness of measures (e.g., Grubesic, 2010).

Comparing the outcomes in a geography of interest with one or more best practice models adopted by other locations is a fourth option. Such comparisons could use statistical techniques. More often they are based on detailed case studies that build on ethnographic work, perhaps complemented with quantitative comparisons. This latter approach also allows us to gain deeper insights into which policy designs might be particularly effective. It also facilitates additional forms of learning from the experience of others.

5 Practical considerations of IIJA program monitoring

Monitoring accompanies all stages of policy development beginning with implementation and pursues multiple, interrelated objectives. It is first and foremost a set of techniques and principles that help track the progress of a project and compare actual to planned timelines and outcomes. Methods such as performance reviews, financial audits, and risk management also help to identify risks and factors that might jeopardize the success of a project to adopt remedial measures (also referred to as "controlling"). In the context of government programs, monitoring also offers important tools to assure transparency, accountability, and compliance.

For the purposes of this report, we will discuss steps to practical implementation for infrastructure projects, digital equity initiatives, and the assessment of broader community outcomes of these policy initiatives. In each case, we will briefly discuss the role of monitoring, the issues that must be addressed to obtain reliable evaluations of program effects and impacts, and the data sources available in addition to sub-awardee performance reports that can be utilized for these purposes. We will discuss problems specific to evaluation in the next section. Section six will extend the discussion with additional considerations, such as data limitations and sharing.

5.1 Monitoring of infrastructure deployment

Monitoring of deployment and adoption of broadband must start as awards were made to sub-awardees. Data on outputs will primarily be drawn from the reports required by the sub-awardees and they will document the situation in project areas. Statutory provisions, requirements in the NTIA NOFOs, and any additional KPIs adopted by the states will be collected. For BEAD, they include metrics derived directly from the sub-awardee reports, such as the number of unserved locations that were connected, information on the technology and quality of the deployed connections (e.g., supported download and upload speeds, latency), and information on low-cost

pricing options. Similarly, metrics on the output of programs aiming at increasing digital literacy will have to be collected from grantees.

State Broadband Offices (SBOs) will be able to use the reported data to generate higher-level comparative metrics, such as the average subsidy per connection in different project areas or the subsidy required to train an adult in digital literacy. Metrics such as the level of adoption (the "take rate") of the newly available service is also of interest at this stage. However, adoption is also affected by factors that are only indirectly or not at all affected by policy choices, including sociodemographic factors and economic factors beyond the control of the BEAD and DEA programs. Thus, even at the early stages of monitoring, it may be necessary to consider other factors that influence short-term outcomes.

Table 1 above lists the statutory and administrative reporting requirements established to support transparency, accountability, and safeguard compliance. Table 2 lists important baseline metrics. Several public and private data sources documenting the state of broadband are available. Here we will focus on data sources that can be used to monitor these important outcome areas in the short, medium, and long run. We will also provide examples of indicators and metrics that allow tracking over time. The arrangement of metrics and variables and the color codes in the tables correspond to Figure 1.

Table 3. Network availability, affordability, and adoption

Indicator	Examples of metrics	Data sources
Availability	• Number/percentage of broadband serviceable locations (BSLs) that are connected (at different speeds) • Number/percentage of BSLs that are unserved/underserved	• Sub-awardee performance reports • FCC Form 477 data, https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477 (2008-2022) • FCC Broadband Data Collection (BDC), https://www.fcc.gov/BroadbandData (2022-present)

		• State broadband data collection and broadband maps • Local broadband data collection and maps
Availability	• Technology used to provide connectivity (e.g., coax cable, fiber, FWA, 5G, satellite)	• Sub-awardee performance reports • FCC Broadband Data Collection (BDC), https://www.fcc.gov/BroadbandData (2022-present)
Availability	• Quality of connections (e.g., download/upload speeds, latency, reliability)	• Sub-awardee performance reports • FCC Broadband Data Collection (BDC), https://www.fcc.gov/BroadbandData (2022-present) • Ookla data, https://www.ookla.com/; • M-Lab data, https://www.measurementlab.net/data/
Affordability	• Broadband prices for different qualities of service, such as speed tiers • Price of low-cost plans • Price of affordable middle-class plans	• FCC Urban Rate Survey (URS), https://www.fcc.gov/economics-analytics/industry-analysis-division/urban-rate-survey-data-resources • Broadband nutrition labels (mandatory since April 10, for largest ISPs, beginning October for smaller ISPs)
Adoption	• Number of households to which service is available that subscribe to broadband (FCC definition) • Number of households in an area that subscribe to broadband (Pew definition)	• Available in FCC Form 477 data, but considered non-public; state Public Utility Commissions have access to the data • American Community Survey (ACS) • Local Estimates of Internet Adoption (NTIA/U.S. Census Bureau Project LEIA)
Change from baseline	• Change from baseline = (Value at observation period minus value at start time) • Percent change from baseline = (Value at observation period minus value at start time)/(Value at start time)	• For all availability, affordability, and adoption metrics changes from the baseline can be calculated, for a given time interval, such as six months
Gap to goal	• Gap to goal = (Goal value minus value at observation period) • Percent gap to goal = (Goal value minus value at observation period)/(Goals value)	• For all availability, affordability, and adoption metrics the remaining gap to the envisioned goals at the observation period can be calculated, for a given time interval, such as six months

Source: own compilation.

The preeminent objective of the Bipartisan Infrastructure Bill is to connect all unserved locations to broadband with at least 100/20 Mbps download and upload capability and, if funds are remaining,

to upgrade all underserved locations to that level of service. Initially, this information will only be available from the sub-awardee reports. Carefully designed and enforced reporting requirements will therefore be vital. Data on the state and quality of network infrastructure beyond the unserved locations is increasingly abundant. After a while, often between six months and two years, the newly connected, previously unserved locations will also be included in public databases. However, the quality, accuracy, spatial granularity, and frequency of data collection of data courses varies. Consequently, not all data is equally well suited to support program monitoring.

From 2022, the greatly improved data from the revised FCC Broadband Data Collection (BDC) is available.[12] It overcomes some but not all of the weaknesses of the prior data source, FCC Form 477 data. Whereas the data is more granular and hence more accurate, it continues to rely on data that is self-reported by service providers. Although a challenge process was established that helps improve the accuracy of the data over time, no independent verification of the data is required. Data on adoption continues to be collected as part of Form 477 reporting, but only highly aggregated information is available in the public domain. More detailed information on the prices of broadband service is limited to urban areas and no corresponding data collection for rural prices is currently planned.

SBOs should also monitor changes of metrics over time. For all availability, affordability, and adoption metrics absolute changes and rates of change relative to the established starting point (baseline) can be calculated. Similarly, the gap and the percentage gap to the envisioned goal can be calculated and can facilitate tracking of project progress. Not all deviations from an envisioned timeline and milestones are necessarily alarming, as supply chain and other factors may come into

[12] See FCC, Broadband Data Collection, retrieved on September 16, 2024, from https://www.fcc.gov/BroadbandData.

play. Good monitoring will seek plausible explanations for such deviations and require remedial measures if necessary.

5.2 Monitoring digital equity and inclusion

Digital equity has multiple components. It can be measured using one or more of the individual indicators listed in Tables 3 and 4 or it can be based on a score that aggregates individual indicators. Indices are popular ways of representing digital equity. Although having one number is appealing, it usually obfuscates the underlying diversity of factors. Methodologically, indices raise difficult issues, such as how individual components should be weighted. Radar diagrams or sliding scale diagrams that display component scores are typically preferable and can be effective ways to visualize multiple individual indicators. They have the advantage that they depict the achievement for each individual indicator in one easy-to-understand graph. They also allow defining thresholds that signal goal achievement. Examples of such visualizations are the OECD Going Digital Toolkit,[13] the Network Readiness Index,[14] and the Digital Opportunities Compass.[15]

Table 4. Digital literacy and digital equity

Indicator	Examples of metrics	Data sources
Indicators for covered populations	• Requirement 2 of the NTIA Digital Equity NOFO requires states to select metrics for the eight covered populations. These state-chosen metrics then will have to be monitored.	• U.S. Census Digital Equity Act Population Viewer, https://mtgis-portal.geo.census.gov/arcgis/apps/webappviewer/index.html?id=c5e6cf675865464a90ff1573c5072b42 • Specialized state surveys • Surveys by specific groups, possibly added to other surveys (e.g., Veterans Affairs)
Digital literacy	• Knowledge of users and their ability to perform digital tasks	• As of July 2024, there is no systematic, granular, national data source available

[13] https://goingdigital.oecd.org/, visited July 13, 2024.
[14] https://networkreadinessindex.org/, visited July 13, 2024.
[15] https://quello.msu.edu/wp-content/uploads/2023/02/Digital-Opportunites-Compass-Paper-20220223.pdf, visited July 13, 2024.

		• Several national surveys assess digital skills (e.g., Sidoti & Vogels, 2023) • Several state surveys assessed uses of the Internet for planning volumes • Social science has generated robust measurement scales for digital skills
Proxies for digital literacy	• Highest formal educational achievement	• U.S. Census • American Community Survey (ACS)
Cyber-security skills	• Cybersecurity practices of individuals, organizations in a geography	• Occasional surveys, there does not seem to be a consistent, reliable source
Digital equity	• Individual digital equity indicators • Digital equity index • Gini index of digital equity	• Digital equity surveys developed by states

Source: own research.

In their digital equity plans, states selected indicators and metrics to assess digital equity with regard to the eight covered populations. These are Individuals who live in households with an income of 150% or less of the federal poverty level; aging individuals (60 and above); incarcerated individuals, other than individuals who are incarcerated in a Federal correctional facility; veterans; individuals with disabilities; individuals with a language barrier, including individuals who are English learners and have low levels of literacy; individuals who are members of a racial or ethnic minority group; individuals who primarily reside in a rural area. States also define broader digital equity goals.

Monitoring in the digital equity area typically will focus on two aspects. As in the case of infrastructure, it will be important to track the progress of projects funded from DEA appropriations. Metrics will have to be based on the project proposal and the agreed deliverables (e.g., the number of adults trained in digital and cybersecurity skills). There is also a role for the monitoring of other digital equity goals, such as the state-wide level of digital literacy. In the case of digital equity, it will be more difficult to establish a causal link between policy interventions and outcomes, because

many other factors are in play. We will return to this question on the next section, which will discuss evaluation.

5.3 Monitoring broader community outcomes

A wide range of metrics is available that can be used to assess aspects of the broader community impacts of broadband. Table 5 lists data sources that measure selected economic, social, and political community outcomes. Broader community outcomes will typically materialize with variable time delays. The magnitude of these delays is not well understood. Thus, simple monitoring of indicators and metrics related to broader community outcomes will only be of limited value. Methods of evaluation and empirically more robust research methods will be needed, as will be discussed in more detail below.

Table 5. Broader community outcomes

Indicator	Examples of metrics	Data sources
Jobs	• Availability and quality of jobs available in a community	• U.S. Bureau of Labor Statistics (BLS), https://www.bls.gov/emp/
Income	• Average or median individual income • Average or median household income • Income distribution by quartile or decile	• U.S. Census, Income Tables, https://www.census.gov/topics/income-poverty/income/data/tables.html
Growth	• Local economic growth • Population growth	• Bureau of Economic Analysis (BEA) gross domestic product data, https://www.bea.gov/data/gdp/gross-domestic-product • U.S. Census Bureau population data, https://www.census.gov/topics/population.html
Education	• Quality of education system and community education level	• U.S. Department of Education (DoE), https://www2.ed.gov/rschstat/landing.jhtml?src=ft • National Center for Education Statistics (NCES), https://nces.ed.gov/
Health	• Community health indicators	• University of Wisconsin, Madison, Population Health Institute, https://uwphi.pophealth.wisc.edu/

Civic participation of citizens	• Share of the sociodemographic groups participating in community discussions	• Pew Research Political & Civic Engagement data, https://www.pewresearch.org/topic/politics-policy/political-civic-engagement/ • AmeriCorps Civic Engagement data, https://www.pewresearch.org/topic/politics-policy/political-civic-engagement/

Source: own research.

It may be tempting to simply correlate the availability of broadband with broader community outcomes without controlling the contribution of other factors. Although this is not always wrong, it will most likely yield biased and incorrect results because it ignores the effects of other factors that are in play, as discussed in sections four and five. Selection of appropriate statistical methods, such as multiple regression analysis, is therefore critical. Where possible, it is recommended that longitudinal methods, such as panel data analysis, are employed. This allows determining the effects of broadband with greater accuracy and reliability.[16]

[16] See, for example, the work by Whitacre et al. (2014), and Whitacre and Gallardo (2020).

6 Practical considerations of IIJA program evaluation

Monitoring is indispensable to track project success, create transparency and accountability, and assure compliance with the relevant rules and regulations. However, it can only partially answer the question whether the adopted policies worked and how effective they were. With the exception of situations were fraud is in play, monitoring may not be able to answer the question of why a policy failed or was ineffective. For these purposes, evaluation tools, which seek to develop causal explanations of the factors influencing outcomes such as infrastructure investment, digital equity, and broader community effects, are needed.

Because of the multitude of factors that are in play, the many positive and negative feedback effects and the variable time delays, the impacts of infrastructure investment on digital equity and broader community outcomes are most difficult to assess. This is less a question of finding the right indicators, but it is primarily a challenge of establishing statistically robust causal links between broadband availability, adoption, and outcomes. It is important to select an appropriate counterfactual against which developments in a specific area can be compared and appropriate analysis methods. To do this well, requires reliable data on the other factors depicted in Figure 2, the plethora of policy interventions and contextual factors, such as socio-demographic characteristics of a community.

6.1 Dealing with multiple policy initiatives

An evaluation of policy interventions would ideally isolate the contribution of a specific policy program to the achievement of state goals. In the case of the programs adopted in the IIJA this is complicated by the fact that numerous other policy interventions aim at advancing broadband also. Admittedly, BEAD is a very large program, and one could argue that its effects likely dominate other

efforts. Although this may be an outcome of an evaluation, it should not be assumed without examination.

A pragmatic approach that seeks to keep the task manageable would assess the interactions between IIJA and the largest other programs. Ideally, these programs will mutually reinforce each other. For example, the demand-side subsidies provided by ACP reduced the supply-side subsidies needed to incentivize ISPs to extend the network to additional locations. In other words, any given supply-side stimulus had further-reaching effects.

However, the coexistence of programs with different goals, eligibility criteria, and timelines may send mixed signals to public and private investors. For example, 5G Fund subsidies designed to extend wireless broadband may increase the subsidies needed by ISPs to extend wireline access. This could happen if subsidies to wireless providers lower the take rate, that is, the percentage of households who subscribe to a network that passes their location.

Unfortunately, there is no comprehensive database available that would allow tracking federal, state and local programs intended to stimulate broadband deployment and adoption. The FCC broadband funding map (https://fundingmap.fcc.gov/home) provides information on 10 programs administered by the FCC, NTIA, the Rural Utilities Service, and the U.S. Department of Treasury. Although the map represents only a partial list of programs, and not all funding details are accessible on the map, it is a start. Additional information is available from the institutions administering programs.

Table 6. Broadband policy affecting infrastructure deployment

Program	Agency	Funding	Examples of metrics	Data sources
BEAD	NTIA	$42.45B	• Allocation by state • Awards to individual projects	• https://www.internetforall.gov/

			• Project award per additional connection	• Will become available from states as BEAD is implemented
Digital Equity Act programs	NTIA	$2.75B	• Allocation by state • Awards to individual projects • Awards per participant	• https://www.internetforall.gov/program/digital-equity-act-programs
Middle Mile Program	NTIA	$980M	• Awards to middle mile projects	• https://www.internetforall.gov/program/enabling-middle-mile-broadband-infrastructure-program
Tribal Broadband Connectivity Program (TBCP)	NTIA	$3B	• Awards to Native American Communities	• https://www.internetforall.gov/program/tribal-broadband-connectivity-program
Connecting Minority Communities (CMC)	NTIA	$268M	• Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Minority-Serving Institutions (MSIs)	• https://www.internetforall.gov/program/connecting-minority-communities-pilot-program
Broadband Infrastructure Program (BIP)	NTIA	$288M	• Expansion of Internet access to areas without service, especially to rural areas	• https://www.internetforall.gov/program/broadband-infrastructure-programs
Capital Projects Fund	US Treasury	$10B	• Funds eligible states, territories, freely associated states, and Tribal governments can apply for funding to build high-speed Internet infrastructure	• https://home.treasury.gov/policy-issues/coronavirus/assistance-for-state-local-and-tribal-governments/capital-projects-fund
Connect America Fund (CAF)	FCC	$4.1B	• Modernization of universal service fund to support broadband	• https://www.fcc.gov/general/connect-america-fund-caf;
CAF Phase II	FCC	$1.49B	• Support for broadband to unserved areas	• Connect America Fund Phase II Auction (Auction 903), https://www.fcc.gov/auction/903
Lifeline program	FCC	$610M	• Provides a discount to low income consumers, at or below 135% of the federal poverty line	• https://www.fcc.gov/lifeline-consumers
E-Rate (schools, libraries)	FCC	$2.1B	• Supports broadband to schools and libraries	• https://docs.fcc.gov/public/attachments/DOC-401168A1.pdf
Rural health care	FCC	$493M	• Supports broadband to rural health care providers	• https://www.fcc.gov/general/rural-health-care-program
RDOF	FCC	$20.4B	• Supports provision of broadband to unserved locations	• https://www.fcc.gov/auction/904

5G Fund	FCC	Up to $9B	• Deployment of 5G wireless to unserved locations	• https://www.fcc.gov/5g-fund
Affordable Connectivity Program (ACP, ended)	FCC	$14.4B	• Provided $30 subsidies to qualifying households (e.g., below 200% of federal poverty	• https://www.fcc.gov/acp
ReConnect Grants and Loans	RUS	Up to $400M for grants; up to $300M for loans	• Facilitates broadband deployment in areas of rural America that currently do not have sufficient access to broadband	• https://www.usda.gov/reconnect/program-overview
State grant and loan programs	States		• Various state level programs	• See this report
Total Funding		$113.03B		

Source: own research.

In total, more than $113B has been channeled to support supply- and demand-side broadband programs. In addition to these measures, legal and regulatory measures, such as the treatment of access to rights of way (ROW) and the regulations governing the ability of municipalities to offer broadband, influence network deployment.

6.2 The importance of considering contextual factors

Contextual factors act as amplifiers or impediments that influence how additional broadband connectivity translates into broader community outcomes. Several of these contextual factors are, in turn, changed as digital connectivity becomes more widely available.

Table 7. Contextual factors

Indicator	Examples of metrics	Data sources
Income	• Socio-demographics of location (census tract and higher)	• US Census, https://www.census.gov/
Population	• Population density • Population dispersion	• US Census, https://www.census.gov/
Demo-graphics	• Age • Highest formal education	• US Census, https://www.census.gov/

	• Race and ethnicity	
Economic base	• Economic base of location	• US Census, https://www.census.gov/
State government	• Political orientation of government	• Kaiser Family Foundation (KFF), https://www.kff.org/other/state-indicator/state-political-parties/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D
Topology	• Indicators measuring the difficulties of serving customers in the terrain (e.g., average gradient)	• United States Geological Survey (USGS), https://www.usgs.gov/science/faqs/about-usgs
Land values	• Average or median house price	• National Association of Realtors, https://www.nar.realtor/research-and-statistics

Source: own research.

6.3 Evaluation of infrastructure investment

Numerous studies have examined the effects of broadband policy on infrastructure investment. These studies use a variety of measures, including qualitative and quantitative methods. The overall picture is varied and shows many nuances associated with program impacts. For example, LaRose et al. (2014) found that the Broadband Technology Opportunities Program (BTOP) improved broadband access but that the benefits of the program were for historically marginalized populations were smaller than for other groups. Other studies have found no impact of the same program (Beard et al., 2022). More recent studies of demand-oriented programs such as ACP find noticeable impacts on low-income groups (Horrigan, 2024). In their evaluation of the Internet Essentials program, Rosston and Wallsten (2020) found limited impacts on participants on adoption only.

Robust evaluations of the impact of IIJA on infrastructure deployment must carefully select control variables, that is factors that influence investment but are independent of policy choices. These include variables listed in 6.2 under contextual factors and other policy interventions that might interact with IIJA programs. These factors will likely vary by location, so the granularity of the

evaluation will have to be carefully designed. Moreover, there will likely be interactions between locations that may have to be controlled. Technically, this can be done with a variety of multiple regression analytical methods. Spatial regression analysis can be used in cases where there are strong interdependencies between geographic areas. One challenge is that all geographic areas across the country are affected by the policies, which makes finding a counterfactual challenging. Methods of benchmarking and frontier analysis could overcome that challenge as well as regression discontinuity designs (RDDs).

6.4 Evaluation of digital equity

There is a similar rich research literature on digital divides, digital inequality, and how to alleviate them (e.g., Robinson et al., 2020a; Robinson et al., 2020b). Several advocacy communities are promoting the cause of digital equity. Some of them, such as the National Digital Inclusion Alliance (NDIA) seek to advance digital equity and inclusion very broadly. Others, such as the Schools, Health & Libraries Broadband Coalition (SHLB), advocate with specific sectors in mind. Moreover, numerous non-profits, such as Tech Goes Home, work with individuals to improve digital skills. More such initiatives will be funded in the impending digital equity funding program.

The direct and indirect contributions of DEA and BEAD programs on digital equity and the uses of broadband raise unique evaluation issues. DEA directly programs aim at improving digital literacy. Unlike BEAD projects, which are geographically targeted to specific, unserved locations, digital equity programs are not limited to unserved locations or populations, even though they might attract a larger number of initiatives. This may require an appropriate adaptation of the geographic area for which the monitoring and evaluation activities are conducted. Moreover, broadband availability also may have indirect effects on digital skills. For example, empirical research shows (e.g., Hampton et al. 2021) that the availability of broadband access will enable trial-and-error and

playful learning that will likely contribute to digital literacy. Moreover, states plan to embed provider commitments that aim at improving digital literacy into their scoring of BEAD proposals.

An additional challenge is that metrics for infrastructure deployment are more widely developed and available than data documenting digital literacy and uses of broadband. Practitioners and researchers have developed several pragmatic solutions to assess digital skills. They often focus on selected uses of the Internet and self-assessments of the survey participants of their ability to pursue tasks that require different levels of digital savvy.[17] Social scientists have developed comprehensive and robust survey instruments and measures ("scales") that have been used to assess digital literacy and digital skills (e.g., van Dijk, 2005; Hargittai & Hsieh, 2012; Hampton et al., 2021). However, such work is often limited to specific populations and systematic state-wide and nation-wide data that are collected repeatedly over longer periods of time are largely missing. A concerted effort to collect such data would greatly support broadband policy planning and monitoring.

6.5 Evaluation of broader community outcomes

Research on the broader community outcomes of broadband is most challenging due to the time lags involved between broadband investment and observable outcomes. Moreover, there are many other factors in play that interact with broadband and that must be carefully controlled. Evaluations lacking such controls will most likely overestimate the effects of broadband. Despite the need for additional research, several surveys illustrate the range of effects of broadband on socio-economic outcomes (e.g., Gallardo et al., 2018; Briglauer et al. 2024). However, the results are sometimes ambiguous and contradictory. For example, Rosston and Wallsten (2020) evaluated the Internet

[17] Such surveys may be added to already existing data collection efforts, such as in Colorado, where selected digital skills are assessed in the Health Access Survey. Several states, for example Michigan, New York, and Connecticut, have made specific efforts to evaluate digital literacy for covered populations as part of their digital equity plans.

Essentials program. They found positive effects on take up, only limited effects of digital literacy training, and no robust effects of the subsidized computer access component. Zuo (2021), using a triple-differences strategy, found both positive effects on uptake and positive effects on labor force participation and earnings.

Taken together, the variability of findings suggests that the relationships between broadband policy, broadband connectivity, and economic and social development may be less robust than often assumed. It also suggests that there is a need to analyze policy interventions in a broader context, taking variables that affect these relationships into consideration. In addition, the broadband ecosystem encompasses many positive and negative feedback loops, which call for a longitudinal approach.

7 Data collection, curation, and sharing

Data collection, curation, and sharing are essential, integral components of meaningful program monitoring and evaluation (Mack et al. 2019). Because additional data collection is costly, it is important to utilize available data sources where possible and appropriate. However, important areas, such as digital literacy, remain incompletely documented or not documented at all. In this section, we provide an inventory of main datasets and their strengths and limitations. We also develop guidelines for the development of a data management strategy.

Where data is missing, the costs and benefits of new data collection initiatives need to be weighed carefully. Ideally, data would be collected over time so that meaningful comparisons to the baseline are possible and changes can be documented. Broadband network capabilities could be used to collect some data, such as information on broadband uses, at very low cost if sufficient safeguards to protect the privacy of individuals and the proprietary nature of some information could be

established. In other areas, such as the prices of broadband services, digital technology could help to greatly reduce the costs of data collection and curation.[18]

In addition to a comprehensive approach to data collection early during program implementation, it would be desirable to develop a framework for the curation and sharing of data. Data curation refers to the organization and integration of data collected from different sources. This includes cleaning, documenting, maintaining and making the data accessible for others. Whereas not all data may be openly sharable, open data have many benefits. For one, they will facilitate transparency and accountability. Moreover, open data often stimulates innovations by communities of practitioners, and they facilitate learning from documented experience.

7.1 Untimely, incomplete, and missing data

Untimely, incomplete and missing data greatly complicate monitoring and evaluation. Detailed data that can be brought to evaluating progress toward the IIJA goals is available from several federal agencies, but there are often considerable delays before the information is published. In addition, data may be updated in subsequent revisions, sometimes with non-marginal changes in the initial numbers. For example, the FCC publishes annual reports on the progress to achieving advanced telecommunications connectivity for all Americans, based on a mandate established in Section 706 of the Telecommunications Act of 1996.[19] Starting in 2024, these Section 706 Reports rely on information from the more accurate Broadband Data Collection (BDC). However, the 2024

[18] Starting in April 2024, large ISPs had to implement the FCC-mandated broadband nutrition labels that summarize price information in a concise, standardize format. Starting in October 2024, smaller ISPs are also required to publish pricing information. These labels could, at least in principle, be examined with methods of computational data analysis. Researchers have developed several tools, such as the broadband query tool (BQT), that could be deployed for this purpose (e.g., Paul et al., 2023).

[19] The most recent release, the 2024 Section 706 Report, is available at https://docs.fcc.gov/public/attachments/FCC-24-27A1.pdf. The names of the report varied over time. It was initially referred to as the Broadband Progress Report, and later as the Broadband Deployment Report (BDR). In 2024, the name was modified to the generic Section 706 Report. See also the discussion in Kruger (2017).

Report was based on data for December 2022 and the 2025 Report will use December 2023 information. The time lag is a little shorter in the Communications Marketplace Report issued biannually by the FCC, but it is at least one year. Similar long delays affect data released by the NTIA, BLS, BEA, and U.S. Census. This implies that real-monitoring will have to rely initially on data generated by award recipients and state data collections.

Incomplete or fully missing data pose even greater obstacles. They affect several areas that are important for monitoring and evaluation. The most important gaps are granular information on the price of broadband at various speeds, aspects of service quality (e.g., network reliability), and digital skills. Based on specific legal mandates, the FCC currently collects only very limited price data: urban rates and international broadband price data. The Urban Rate Survey is designed to document undiscounted list prices for broadband service in urban areas.[20] While statistically carefully designed, it was developed with the specific purpose in mind to establish a threshold for determining whether rural service was "comparable" to urban service. No comparable data collection is currently planned for rural locations. In principle, the broadband labels could fill this gap, but the data is currently not systematically collected. Moreover, the labels only document a selected subset of prices and not the full diversity of available rates. Data from private sources, such as the data collected by Broadband NOW, is often outdated and the statistical veracity of the information is difficult to ascertain. Several private firms collect information but that is not available in the public domain.[21] Moving forward, policies that require these data to be made available should be put in place. These policies should specify the aggregation levels at which

[20] https://www.fcc.gov/economics-analytics/industry-analysis-division/urban-rate-survey-data-resources, visited July 13, 2024.
[21] Consumer Reports (2022) conducted a study based on a convenience sample of bills submitted by subscribers. Several financial advisory firms, such as J.P. Morgan, collect selected broadband data.

reporting is acceptable (e.g., individual providers, Census tracts) and documentation standards for these data.

Another area where data is scarce is digital literacy. In general, it is important that states make information they have collected publicly available. In other areas, information that may have been collected will cease to be collected. For example, the ACP data formerly provided by the Universal Service Administrative Company (USAC) will no longer be updated after the termination of the program (unless new funding is authorized). Lastly, it is important to note that guidance about metrics would be helpful to getting consistency between the states in terms of the type of data that are collected and reported. This consistency will help with comparison between states, where relevant.

7.2 Open or proprietary data

Transparency, monitoring, evaluation, and policy learning are facilitated if data are available publicly. The creation of public repositories that are accessible on the Internet is critical to the evaluation of BEAD outcomes. It will enable individuals outside of state policy offices to contribute to the formation and implementation of digital equity plans. This includes survey and interview data, which can be shared with the general public as long as these data are de-identified to remove participant names and any other information that would make the identification of participants possible. Beyond research and policy evaluation efforts, the creation of data in the public domain will also build a community of researchers and experts.

Proprietary data, which are data that cannot be made available in the public domain may be needed to protect the privacy of individuals. It may also be appropriate to protect commercially sensitive information in areas with few providers. In the event proprietary data are necessary it is still necessary to document where, who, and how data were collected from. It is also necessary to

document how data was processed and the limitations of this data. Critical information about processing includes the treatment of outliers (e.g., retained or removed), any aggregation of data from the individual level to other levels, whether that is the creation of groups or aggregation to spatial units (e.g., Census tracts, counties), also need to be documented.

7.3 Data documentation and management

Requirements for data documentation should specify metadata standards (see https://atlan.com/metadata-standards/). The selection of metadata standards should consider the purpose of the data. Geographic data, for example, have specific standards (e.g. FGDC). Documentation of data also needs to include important nuances to these data. For example, data about broadband adoption needs to include specifics about the population of interest because these subtle differences can produce different numbers about the same phenomenon. The NTIA and FCC quantify adoption based on homes passed by Internet service. In contrast, Pew Research measures adoption as the share of households in a geographic area that subscribe to broadband relative to all households.

7.4 Data visualization

One of the means of making data available to decision makers and the public is the use of data visualization. Advances in user-friendly software, such as Tableau or MS Power BI allow translating data tables into static and dynamic visualizations. Recent examples include various dashboards, such as the visualizations by Hernan Galperin and François Bar on the future of the Affordable Connectivity Program[22] or the ACP Dashboard created by the Institute for Local Self-Reliance.[23] In

[22] Hernan Galperin & François Bar, The Future of the Affordable Connectivity Program, https://arnicusc.org/the-future-of-the-affordable-connectivity-program/.
[23] Institute for Local Self-Reliance (ILSR), Affordable Connectivity Program, https://acpdashboard.com/.

addition, advances in spatial mapping capabilities facilitate the creation of layered maps, such as federal and state broadband maps.[24]

Although visualizations can be powerful means of representing data related to broadband policy caution is also in order. Because multiple factors are in play, visualizations of the association of two or more factors may inadvertently suggest a causation where none exists once appropriate statistical controls are applied. To avoid this problem, dashboards could be enhanced and made into predictive tools by including statistical estimation routines and simulation techniques. These tools would run in the background of the visualization and could greatly assist in refining policy decisions.

[24] See, e.g., the Broadband Navigator, and interactive portal developed by the Washington State Department of Commerce, https://wa.broadbandnavigator.com/map?zoom=7&center=-13487590%2C5993933.

8 Toward promising practices

From the plans developed by states and from past experience, key elements emerge for states to best position themselves to effectively monitor and evaluate progress towards IIJA goals. The following eight steps provide a road map for conducting systematic monitoring and evaluation:

1. Documentation of the starting conditions at the beginning of program implementation (the status quo ante). Much of this is done in the state planning reports.
2. Development of forward-looking plans to monitor key outcome metrics and make sure the data is available, either from public sources, reported by awardees, or collected by the state. Some of this work has been done in the planning reports, but more needs to be done. It would be useful to develop collaborations with broadband offices in other states to create comparable evidentiary evidence.
3. It is important that data generated by awardees and state surveys is made available, as far as possible, in an openly accessible, well documented way with appropriate meta data.
4. Shortly after first outcome observations are available, states should start to create metrics to evaluate how program awards translate into short-term program goal achievement. Table 2 provides a set of suggested metrics, based on the measurement framework of Figure 1.
5. Once state outcomes data for network deployment become available, it is possible to get an initial understanding of the effectiveness of programs. Three types of comparisons are possible and meaningful: (a) comparisons against the state's own past record, (b) comparison against peer groups, and (c) comparisons with more promising performers
6. As time passes, initiatives that may take longer to show effects can also be evaluated. This includes digital literacy initiatives and an assessment of broader community outcomes.
7. Eventually, with more information available, it is highly recommended to conduct more rigorous statistical evaluations of outcomes. The methods discussed in this report can

contribute to identifying programs that work well and phase out measures that have more limited effects.

8. Ideally, rational policy makers will adapt the chosen policy approach in light of the evidence created by these assessments.

Aside from publicly available data for assessing progress over time and comparing the performance of states, participating in forums of intrastate and interstate entities is also critical for knowledge sharing. The digital inclusion community holds regular online meetings and regional and national conferences. NTIA has orchestrated several working groups and established liaisons with each state. Intra-state forums exist in many states and can create peer groups of communities within the same state that are addressing similar challenges or are seeking to serve similar populations. Digital navigators may also be a means of connecting peer groups within states.

Lastly, it is important to make plans for the sustainability of initiatives and programs at the outset to avoid problems encountered with previous broadband programs, such as the Broadband Technology Opportunities Program (BTOP). Program design and reporting should also be flexible enough to incorporate new and emerging issues related to broadband deployment and digital equity. Viewing programs as a starting point for future work rather than a moment in time with specific start and end dates would help shape how elements are designed and sustained.

9 Conclusion

Systematic monitoring and evaluation during the decade-long broadband infrastructure initiative authorized by the IIJA helps decision makers to improve approaches and to increase the effectiveness of the programs. This report presents a framework, methods, and workable metrics that can accomplish these tasks during different implementation stages. It emphasizes the importance of establishing a clear initial starting point, the selection of meaningful baselines to which outcomes can be compared for the duration of the program and discusses statistical tools that can be used to assess and improve the effectiveness of the overall package of measures.

Given the rapid pace of technological change, broadband policy is an evolving project. The overarching goal of this report is to initiate the development of a distributed knowledge and learning environment to base broadband policy on solid evidence. The report proposes metrics to document the initial starting point, metrics to monitor annual changes, and several approaches to benchmark the experience of a specific community or state. It also recognizes that evidence alone is not sufficient for successful policy. It is also necessary to understand the working and dynamics of the broadband ecosystem as this will help inform necessary adjustments and adaptations as experience with the initial measures becomes available.

This report presents a broad range of public and private data sources that can be brought to the evaluation of the IIJA. However, it also showed that in critical areas systematically collected, representative information is missing altogether, is incomplete, or may only be released with a considerable time delay that greatly diminishes its value. Some metrics, such as the number of connections of previously unserved locations, can be obtained based on regular and verified reporting by awardees, without overburdening the recipients of the funding. For other metrics, such as better data on digital literacy and uses, states may be able to add selected survey questions to

other, already existing survey instruments or to design specialized new surveys. It is also desirable to develop standardized approaches to data curation and documentation.

We recognize that the work presented in this report is only the very beginning and hope that it will stimulate additional discussions and developments. Monitoring and evaluation, like policies to close the digital divides, also benefits from local knowledge and insights. The framework presented here can be adapted to local circumstances and customized to the specific needs of a community or a state. At the same time, it would be desirable to develop a common set of principles for evaluation and shared data collection and documentation practices, as these would improve the ability of states to learn from each other. Both successes and failures offer valuable lessons and can help finding a better path forward. States have long been hailed as laboratories in which innovative solutions to societal problems emerge. Broadband is no different.

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