8-8-2010

Demand-Side Programs to Stimulate Adoption of Broadband: What Works?

James Prieger
Pepperdine University, james.prieger@pepperdine.edu

Janice A. Hauge
University of North Texas

Demand-Side Programs to Stimulate Adoption of Broadband: What Works?

Janice A. Hauge, *University of North Texas*

James E. Prieger, *Pepperdine University*

August 8, 2010

Abstract
We examine the evidence available on the efficacy of demand-side programs intended to stimulate broadband adoption. We review studies that attempt to measure results. Our suggestions for future program evaluations are to include cost-benefit analysis as a standard part of program review and to make clear that the purpose of evaluation is to assess progress made toward the ultimate policy goals rather than the program's proximate implementation goals. Appropriate data must be collected to draw conclusions, and appropriate statistical methods must be used to determine the causal impacts of a program. This has rarely been done to date.

KEYWORDS: Internet, broadband stimulus, demand study, digital inclusion

Author Notes: The project received financial support from AT&T. All analyses and conclusions are those of the authors alone.

Revised version published as Janice A. Hauge and James E. Prieger, "Demand-Side Programs to Stimulate Adoption of Broadband: What Works?" *Review of Network Economics*, Vol. 9, No. 3, Article 4 (2010). Please cite published version.

1 Introduction

In February 2009, as part of the American Recovery and Reinvestment Act (the "stimulus" bill), Congress directed the Federal Communications Commission (FCC) to develop a plan that "seek[s] to ensure that all people of the United States have access to broadband capability." The National Broadband Plan (FCC, 2010), released in March 2010, makes it clear that to make further inroads into the segments of the population that have not adopted broadband, attention must be paid to both the supply and demand sides of the market. While policy attention at the federal and state levels toward broadband has previously been directed mainly at the supply side in the US, a growing consensus argues that the demand side cannot be ignored.[1] While definitive broadband mapping is still being planned and carried out in the US, data that we currently have suggests that broadband is available to the large majority of households.[2] There may yet be much work to do to push the broadband network into the remaining unserved areas of the country, and there is clearly a role for policy if extending availability to areas currently deemed unprofitable by the market is the goal.

However, attention should not remain exclusively on the supply side. Gillett, *et al.* (2006, p.11) state that,

> Once broadband is available to most of the country, differences in economic outcomes are likely to depend more on how broadband is used than on its basic availability. The implication for economic development professionals is that a portfolio of broadband-related policy interventions that is reasonably balanced (i.e., also pays attention to demand-side issues such as training) is more likely to lead to positive economic outcomes than a single-minded focus on availability.

---

[1] During the ongoing FCC proceedings for the development of the National Broadband Plan, Intel Corp. (2009) noted that "more than one hundred parties commented on the importance of adoption and demand-side programs in the National Broadband Plan."

[2] A recent survey from the Pew Internet & American Life Project indicates that only 4 percent of adults in the US report that they do not subscribe to broadband because of lack of availability (Horrigan, 2009b, p.42). An even later survey commissioned by the FCC found that this figure has dropped below 2 percent (i.e., only 5 percent of the 35 percent of Americans who do not use broadband at home gave availability as their main reason for non-use).

Since that statement was made, infrastructure deployment has continued to increase, and opportunity for access now rapidly approaches ubiquity in the US. Consequently, the most cost-effective options to achieve the goals of the National Broadband Plan for continued gains in the level of adoption come from the demand side. As the cost of connecting the last few pockets lacking broadband infrastructure in the US begins to rise steeply, stimulation of demand looks ever more efficient.

The US Congress has determined that stimulating demand for broadband is necessary, by requiring the FCC to create in the National Broadband Plan "a detailed strategy for achieving … maximum utilization of broadband infrastructure and service by the public…."[3] The first task for the policy community should then be to determine the most effective means to increase demand for broadband service, so that effective methods can be replicated and expanded. Given the stakes, the standards of evidence for the success of a policy should be set high. This leads to our major theme: the body of evidence regarding evaluation of demand-side efforts to encourage broadband adoption is exceedingly thin. A massive review of hundreds of digital literacy programs throughout the OECD countries puts it succinctly: "…it is striking how little evidence initiatives have gathered on the impact of the activities on the participants" (Hilding-Hamann, *et al.* 2009b, p.54). More specifically, Strover (2009, p.213) recently noted that "there is a lack of strong empirical data that would provide compelling evidence that economic and community development goals could be realized through programs that promote computer and Internet access." We agree, and observe that evidence adhering to high econometric standards for causality is especially scant. In particular, researchers must be especially careful to recognize that coincidence of a factor and an outcome does not imply causality. This is sometimes called the Fallacy of False Cause—concluding that the simultaneous presence of two factors means that one caused the other, or, in a statistical sense, that correlation implies causality.[4]

Our two main points, then, are that demand-side policies must take their place alongside supply-side policies if greatly expanded adoption of broadband is the policy goal; and that reliable evidence establishing the effectiveness of existing demand-side policies has been insufficient. The purpose of this paper is to examine carefully the evidence available on the effectiveness of demand-stimulus

---

[3] American Recovery and Reinvestment Act of 2009, sec. 6001(k)(2)(B).

[4] It is important to note that when we refer to the Fallacy of False Cause herein, we are not judging that the presumed causality is not present; rather, that evidence adequate to make such a conclusion has not been presented.

programs for broadband adoption. While we do not attempt to cover every initiative ever tried for demand stimulus—an impractical task at this point, given that some reviews have found nearly 500 demand initiatives[5]—we have attempted to gather all formal evaluations of such programs.[6]

The rest of the paper is organized into three main sections. In section 2, we discuss the general types of initiatives and programs designed to stimulate broadband demand. We organize our discussion of these programs around the barriers to broadband adoption that they tackle. In section 3, we turn attention to evaluations of quantifiable results of such programs. After reviewing the evidence, we turn in section 4 to a discussion of our overall findings on the types of programs that are most effective. We also give suggestions for best practice (or, at least, better practice) for future program evaluation to be performed as an important part of the National Broadband Plan. Section 5 concludes.

2 Types of Demand-Stimulus Programs

There are many different kinds of programs designed to encourage broadband Internet access and adoption. We organize the discussion of the various types of demand stimulus programs by categorizing them according to which of four main barriers to adoption they address: the price of broadband service, lack of computer ownership, lack of digital literacy, and a lack of perceived value of broadband (Horrigan, 2009a, 2009b, 2010). [7]

2.1 Programs to Mitigate Price As a Barrier to Broadband Service

About 10 years ago, it appeared that the cost of subscribing to broadband service was the biggest hindrance to adoption. A 2002 survey of dial-up consumers found that 72 percent of respondents stated that broadband was too expensive as their reason for not upgrading.[8] However, the importance of high price as a bar-

---

[5] See Hilding-Hamann *et al.* (2009a,b), who identified 464 digital literacy initiatives (most with at least some involvement with broadband) worldwide in their research.

[6] Due to space limitations, we do not review every formal evaluation we found in this version of the paper. See the working paper (Hauge and Prieger, 2009) for an expanded discussion of the issues involved and additional citations to program evaluations.

[7] See Horrigan (2009a,b,2010), and a similar survey conducted by Connected Nation (2008). The other top reason for non-adoption is lack of availability (cited by four percent of all respondents, and 17 percent of non-broadband users in Horrigan (2009b)).

[8] The survey statistic is from a Yankee Group survey cited in OTP (2002).

rier to access has declined in recent years. Recent figures from Pew Internet and the FCC show that only about one-third of dial-up users (Horrigan, 2009b) or non-Broadband users in general (Horrigan, 2010) cite that prices would have to fall before they would switch to broadband. Only 10 percent of non-Internet users give "too expensive" as their single reason for not using the Internet (Horrigan, 2009b), although when allowed to select multiple reasons for non-use, about half mention cost (Horrigan, 2010). Even today, prices clearly matter more for particular groups, such as households with low income.[9] There are direct and indirect approaches available for a program trying to break down the cost barrier that may be preventing a household from adopting broadband. We discuss both below.

Direct subsidies aimed at the end-user of broadband (as opposed to the firm deploying the infrastructure) appear to be rare in the US; we are not aware of any states that offer general subsidies for broadband Internet service, and there are currently no such subsidies at the federal level either. However, there are many subsidies and tax credits in the US targeting groups other than the general residential consumer. For example, the E-Rate program for schools and libraries instituted by the Telecommunications Act of 1996 (TA96) is a prime example of a large, targeted subsidy. The E-Rate program is discussed in section 3.

Indirect methods to reduce service prices include policies such as those aimed at demand aggregation. Demand aggregation refers to the practice of forming a pool of potential broadband consumers into a single negotiating unit to face the supply side of the market. While demand aggregation may be used mainly to procure supply for an otherwise un-served area, it also may have elements of interest for demand-side policy (Gillett, Lehr, & Osorio, 2004). Some demand aggregation programs include provisions that mandate rate averaging among customer locations. Thus, demanders who are cheaper to serve (i.e., those in denser areas closer to the middle mile facilities of the provider) implicitly subsidize consumers who are more expensive to connect to the network. Generally, demand aggregation programs appear to be little studied.

---

[9] Although many econometric studies of broadband demand control for income, Prieger and Hu (2008) provide one of the few estimates of the income elasticity of demand: 0.62 (for DSL): i.e., demand decreases as household income falls.

2.2 Programs to Mitigate Lack of Computer Ownership As a Barrier to Broadband Service

Without a computer in the household, broadband adoption at home is either precluded or restricted to more specialized forms of access such as through wireless handsets. However, lack of computer ownership may not be as significant a barrier as some believe. Indeed, recent figures show that only five of the 21 percent of Americans that do not use the Internet say the lack of a computer is what prevents them from using the Internet (Horrigan, 2009b).[10] When allowed to choose more than one reason for non-use, however, 40 percent of non-users of the Internet pick the response "I cannot afford a computer" (Horrigan, 2010).

Still, many broadband programs and policies target computer ownership as the necessary first step toward Internet connection from home. For example, evaluation of the Wireless Philadelphia (now the Digital Impact Group) Digital Inclusion Project showed that "free computer distribution is a critical element of the [project] and central to any early success" (OMG, 2008, p. i). Lee (2009) similarly found that the computer provision component of ZeroDivide's digital inclusion programs in California were crucial in gaining the participation of community members, and that providing broadband access alone would not have provided sufficient incentive for participation.

2.3 Programs to Mitigate Lack of Digital Literacy As a Barrier to Broadband Service

Digital literacy is the "ability to use digital technology, communication tools or networks to locate, evaluate, use and create information."[11] About 11 percent of non-Internet users cite a barrier related to digital illiteracy as the main reason for not connecting, such as difficulty of use, a feeling that they are "too old to learn," or that they "just don't know how" to use the Internet (Horrigan, 2009b).[12] These respondents constitute only about two percent of US households overall.

---

[10] The situation differs in some countries with lower rates of computer ownership. About one third of survey respondents in Portugal without home Internet access reported they did not have home Internet access because they did not have a computer.

[11] See "Digital Literacy Definition and Resources", web page on the University of Illinois at Urbana-Champaign University Library web site, http://www.library.illinois.edu/diglit/definition.html.

[12] However, the importance of digital literacy appears to be higher in Horrigan (2010), which uses different survey methodology: 46 percent of non-Internet users chose "I am not comfortable using a computer" as a reason (possibly among multiple choices) for non-use.

However, digital illiteracy is a larger problem in certain groups. Unsurprisingly, digital literacy is much less prevalent among the elderly and those with less education and income than it is overall. The median age of non-Internet users citing "usability" as a barrier to adoption is 70.[13] Because of the unevenness of digital literacy, most (but not all) programs attempting to further digital literacy target specific groups: the urban or rural poor, the elderly, the undereducated, the unemployed, ethnic and linguistic minorities, the homeless, women, disabled, or at-risk youth (Hilding-Hamann, Nielsen, and Pedersen, 2009a).

Building digital literacy involves specific education and training in the use of computers and the Internet. Such education may be promulgated through Community Technology Centers (CTCs).[14] One of the largest CTC programs is Community Connects, run by the nonprofit group Net Literacy, which has set up more than 200 CTCs.[15] Another large program, ConnectKentucky's No Child Left Offline program, supports after-school digital literacy centers for schoolchildren (ConnectKentucky, 2008)

2.4 Programs to Mitigate Perceived Lack of Value As a Barrier to Broadband Service

Some 22 percent of offline households say that they do not use the Internet because they are "not interested in getting online" (Horrigan, 2009b). Similarly, lack of perceived value is also the barrier for the six percent whose main reason for staying offline is that they "don't need it/don't want it", the four percent who are "too busy/[have] no time", and the four percent who think it is a "waste of time". In a more recent survey, 14 percent of non-Internet users responded either that the Internet is a waste of time or that there is nothing they want to use or see on the Internet as their main reason for remaining offline (Horrigan, 2010).

Policy aimed at increasing the perceived value of broadband for non-adopters can proceed from one of two premises. The first premise is that the consumer is sovereign and has the information needed to make an informed decision whether to subscribe to broadband. Policy based on the premise of consumer sovereignty presumes that since the consumer has revealed his preferences through his market action of not adopting broadband, the value of adopting must be made

[13] All statistics are from Horrigan (2009b).

[14] A CTC is a local program, centered on a physical space, promoting education in the use of technology, typically in economically distressed urban and rural communities.

[15] See www.netliteracy.org/community_connects.asp.

greater to tip the balance. Policies that attempt to increase the amount or utility of content on the Internet fall into this category.

A second premise is that the consumer either does not have enough information to realize what the benefits of broadband are, or (more paternalistically) that the policymaker knows better than the consumer does and must convince him to change his mind. Policy stemming from this premise seeks to "educate" the consumer, where the education is meant to be informative, persuasive, or both.

Programs targeting specific segments of the market with information of particular use continue to have a place. For example, given the relatively quick turnover of small and rural businesses, many owners may be unfamiliar with business use of the Internet and e-business. So, even as residential use of the Internet approaches ubiquity,[16] there may be a continuing role for education of smaller businesses to teach owners how to employ broadband to lower their costs, improve productivity, and expand their markets.[17]

Other "demand-pull" strategies (King, *et al*., 1994) proposed include development of e-government (Turk, Blažič, and Trkman, 2008), disseminating and building knowledge about the new technology among intended adoptees, setting standards, and allowing broadband providers to manage their networks efficiently.[18] The list of potential policy issues that could conceivably affect the demand for broadband and Internet usage is endless. However, with the multifarious nature of the Internet, it is probably wishful to expect much impact from any single policy intending to affect broadband demand indirectly by changing what is available online.

3 Review of Broadband Demand Studies

In this section and the next, we turn to a review and critique of the literature on the success of specific demand-side broadband policies and programs. Such an evaluation is especially important in light of Congress' charge to the FCC to analyze "the most effective and efficient mechanisms for ensuring broadband access

---

[16] Per Horrigan (2010), only 22 percent of adults in the US do not use the Internet or broadband at home.

[17] See Prieger and Heil (forthcoming) for a review of how e-business affects the productivity of firms and other aspects of their business.

[18] Savage and Waldman (2004, 2009) show that it is the promise of greater speed that makes most consumers willing to pay for broadband over dial-up Internet access.

by all people of the United States" in the National Broadband Plan.[19] We begin with a review of broadband demand studies in this section. While many demand factors considered in such studies (e.g., race) are not subject to manipulation by policy, other determinants of demand are (e.g., price). We focus only on the variables considered in such studies that can be controlled by policy. In section 4, we consider the literature evaluating specific programs and initiatives aimed at fostering broadband adoption.

Econometric studies of broadband adoption have identified a variety of socio-economic, demographic, and policy variables that are associated with the demand for broadband, both at the individual and aggregate levels. Ford, Koutsky, and Spiwak (2008) state that demographic and economic endowments explain 91 percent of the variation in broadband subscription across OECD countries.[20] However, many of the results found in studies on broadband demand are of little direct relevance for stimulating demand because policymakers cannot manipulate the demand drivers found (such as race).

On the other hand, policy may stimulate demand for broadband through the price mechanism, and a good understanding of how sensitive adoption is to the price of service is important. In the first of several demand studies using similar methods, Rappoport, *et al*. (2001) found that demand for broadband via cable modem in the US was price inelastic, but that demand for DSL was price elastic.[21] The study also found, unsurprisingly, that DSL and cable modems were substitutes, and so attributed the differences in own-price elasticities to differences in penetration.[22] Crandall, Sidak, and Singer (2002) updated the previous study and found that the elasticities had not changed substantially. But in their own follow-

---

[19] Households' preferences over communication methods have changed greatly over the past 30 years. Analyses of programs designed to encourage adoption of landline telecommunications services are useful as precursors to those current studies that consider programs to encourage adoption of broadband. For detailed information and additional references, see Hauge, Chiang, and Jamison (2009).

[20] Ford, Koutsky, and Spiwak (2008) study fixed broadband adoption, analyzing the per capita broadband subscription rate for each OECD country. They include demographic explanatory variables such as income, age, education, household size, and others.

[21] The elasticity of demand measures the percentage increase in quantity demanded when the price falls by one percent, holding other factors constant. Demand is said to be *elastic* when the elasticity of demand is greater than 1.0 in magnitude and *inelastic* when it is less than 1.0 in magnitude. Inelastic demand would imply that broadband is not very sensitive to price changes.

[22] That is, since cable was more widely deployed than DSL in the first years of broadband in the US, cable modem service often faced no substitutes. DSL service, on the other hand, often faced an intermodal substitute (cable modem service). The presence of substitutes makes demand for a service more elastic.

up study, Rappoport, Kridel, and Taylor (2002) found that demand for the services was becoming more inelastic, perhaps indicating that prices were dropping,[23] penetration was increasing, or that consumers increasingly viewed the services as essential.[24] Dutz, Orszag, and Willig (2009) find that broadband demand elasticity continued to drop during 2005-2008, and therefore that the importance of broadband to household consumers (as measured by net consumer surplus) increased.

Broadband demand studies have also been performed on non-US markets. Ida and Kuroda (2006) found that the demand for ADSL in Japan was price inelastic and that the demand for cable modem and fiber to the home was price elastic, perhaps because of the dominance of ADSL in Japan, consistent with the analyses of Rappoport, *et al*. (2001) and Rappoport, Kridel, and Taylor (2002). Cardona, *et al.* (2007) show that for Europe, the price elasticity of demand for broadband varies with the amount of competition in the market, as is expected with most goods.

Competition is another factor analyzed in many studies, and is another variable that affects broadband prices. In fact, some aggregate studies on broadband penetration include the state of competition in broadband provision instead of prices.[25] Aron and Burnstein (2003) look at the effect of competition (along with other factors) on the broadband penetration rate, which commingles supply (availability) and demand. The authors find that intermodal competition drives increased broadband penetration, reporting that an overlap of cable and DSL availability results in an approximately 6.5 percent increase in adoption per capita. Lee and Brown (2008) use data from the top five OECD broadband penetra-

---

[23] For many forms of demand, including linear demand curves, demand becomes more inelastic as price falls.

[24] At about this same time, Varian (2002) examined consumers' willingness to pay for additional bandwidth for an Internet access service and found that demand was price inelastic, consistent with Rappoport, Kridel, and Taylor (2002). Another study worth mentioning, due to the frequency with which its conclusions are cited in regulatory filings, is the demand estimation of Goolsbee (2006). He finds that demand for broadband was highly elastic in 1998-1999, as estimated from a stated preference survey. He measured the price elasticity of demand for broadband to be -2.75 on average in his sample.

[25] While in some cases the decision not to include prices in regressions of broadband penetration is prompted by lack of price data, there are also sound theoretical reasons for the omission. Broadband penetration in an area is determined by the interaction of availability, supply decisions, and demand for service. As such, service prices are likely endogenous (that is, correlated with the error, which renders least squares regression inconsistent) in the econometric model for the penetration level. Thus, merely regressing penetration on price cannot identify the price elasticity of demand. See Distaso, Lupi, and Manenti (2006) for an approach that uses a model of competition in supply to solve explicitly for a reduced form estimating equation without prices.

tion countries and obtain results similar to Aron and Burnstein (2003). They show that platform competition (along with speed and use of ICT) contributes to adoption, and that these effects are stronger the more similar the market shares are across technologies. Distaso, Lupi, and Manenti (2006) perform a similar analysis using a model of oligopoly competition and data from 14 European countries. They find slightly different results: inter-platform competition drives adoption, but competition in the market for DSL between incumbents and entrants using the incumbent's network does not play a significant role. They also highlight the importance of the prices of substitute goods by stating that increasing the price of local calls (and therefore narrowband Internet access) should encourage consumers to switch to broadband Internet. However, with only seven percent of Americans remaining as dial-up Internet users at home (Horrigan, 2009b), the policy relevance of this finding may be small.

Given the importance of the barriers to adoption of the lack of a computer, digital illiteracy, and lack of perceived value, it would be of great interest to include such factors in demand studies. However, such studies are rare. In one study that investigates such barriers, Cava-Ferreruela and Alabau-Muñoz (2006) show with data from 30 OECD countries over the years 2000 to 2002 that the predisposition to use new technologies (an aspect of digital literacy) appears to be the key driver for demand. More recently, Rosston, Savage, and Waldman (2010) analyze consumer valuation of Internet service to show that such value increases with experience. They conclude that a correctly targeted programs "that educate households about the benefits from broadband (e.g., digital literacy training), expose households to the broadband experience (e.g., public access) or directly support the initial take-up of broadband (e.g., discounted service and/or hookup fees) have potential to increase overall penetration in the United States."

4 Evaluations of Programs Intended to Increase Broadband Adoption

We now critique evaluations of programs designed to spur broadband adoption. We begin with initiatives created for that purpose, and then address policies that have goals other than increasing broadband usage but that nevertheless can have substantial impacts on adoption. Among programs specifically intended to spur broadband adoption, we first consider large national initiatives, and then turn to state and local initiatives of more modest scope.

4.1 National Initiatives

In *hard-intervention* national approaches (using the language of Cava-Ferreruela and Alabau-Muñoz (2006)), government intervenes forcefully in both the supply and the demand side of the market. Given the demand-side focus of this paper, we look only at the latter aspect of these national plans, and use Korea as an example.[26]

Merely having an interventionist government policy does not guarantee broadband success. Aizu (2002) refers to Singapore as an example of intervention without much result (at least by the time of his writing). South Korea, on the other hand, makes nearly every commentator's list of a successful national plan. Lee, O'Keefe, and Yun (2003) and Choudrie and Lee (2004) cite demand-side policy as an important factor in Korea's broadband success, and in particular the Ten Million People Internet Education project. The policy focused on educating homemakers (primarily married women not in the labor force) about the advantages of computer usage and broadband, under the theory that as the principal decision maker regarding household finances, the path to broadband adoption in the home led through the wife. The government provided subsidies for private educational centers to train such homemakers in the use of the Internet. Over one million women received the training.

As evidence of the success of this policy, Lee, O'Keefe, and Yun (2003) point to data showing that a greater proportion of "housewives"[27] use the Internet in Korea than in China, Hong Kong, Singapore, or Taiwan. However, without establishing how many such women would have used the Internet in the absence of the training, the difference among the countries cannot automatically be ascribed to the Korean policy. There may be other cultural and economic differences between Asian countries that might also generate these differences in the data. More informative may be data showing that the gender composition of Internet users shifted substantially toward equality over the years 1999-2002,

[26] Some empirical studies examine the determinants of national penetration rates using cross-country comparisons and data (e.g., Wallsten, 2006; Cava-Ferreruela and Alabau-Muñoz, 2006). A recent study by Belloc, Nicita, and Rossi (2009) specifically examines the impact of demand-side policies in a country on its broadband penetration rate. The authors conclude that demand-side policies appear to be more effective than supply-side policies at encouraging broadband diffusion. The cross-country studies uniformly suffer from a relatively small sample size compared to the number of causal factors the researchers wish to explore.

[27] This term is used in the official English version of the report (KANIC, 2002).

from 33 percent female in 1999 to 45 percent female in 2002.[28] Similarly, from 2001 to 2002, Internet usage by housewives increased from 27 percent to 37 percent. Even these figures do not prove the success of the program, however, for in the absence of national programs specifically aimed at closing demand-side broadband usage gaps (as in the US), lagging groups often tend to catch up over time (Hu and Prieger, 2009). Much stronger evidence would come from comparing gains in usage for women over time in Korea with gains for women in other countries without targeted training programs. Ono (2006) analyzes digital inequality in three Asian countries. He finds that while using the Internet at home (conditional on having a computer) rose significantly for women in Korea between 1997 and 2000, it did not in Japan or Singapore. Thus, while the available analyses cannot speak to how many women in Korea adopted broadband because of the training program, the weight of the evidence points at causality to some degree.

The E-Rate program is one of the few national initiatives in the US (before the National Broadband Plan) designed to increase broadband adoption. The E-Rate program is a federal subsidy program overseen by the FCC and administered by the non-governmental Universal Service Administration Company (USAC).[29] The E-Rate program is the largest explicit subsidy program to date intended to further broadband access in the US, with $2.25 billion authorized each year since 1998 for schools and libraries. The greatest share of the funding (upward of 85 percent), and most of the effort expended evaluating the program, has gone toward schools (Hudson, 2008). The program offers discounts to schools of 20 to 90 percent on telecommunications services, depending on what fraction of their students qualify for the federal means-tested free lunch program.

A study of the first two years of the E-Rate program (Puma *et al.*, 2002) highlights the difficulty of analyzing a policy when data on the pre-intervention state of affairs are not available. In particular, any study of the E-Rate program necessarily suffers from lack of comprehensive data on schools' access to digital technology before the E-Rate was offered. The study used a national survey sample of school information. The main finding of the study is statistically significant

---

[28] The figure for 1999 is from a survey conducted under the auspices of the Korea Network Information Center (KANIC). We could not find a copy of the survey results in English, but they are cited second hand on the World Bank web page "Indicators for Monitoring Gender and ICT" available at http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTGENDER/EXTICTTOOLKIT/0,,contentMDK:20272986~menuPK:562601~pagePK:64168445~piPK:64168309~theSitePK:542820,00.html#_ftnref3. The figure for 2002 is from KANIC (2002).

[29] See Hudson (2004, 2008) and Jayakar (2004) for background material on the E-Rate program.

evidence that availability of digital technology, including the fraction of schools and classrooms connected to the Internet, the speed of their Internet connections, and the number of Internet connections per student, increased in schools supported by the subsidies. When it comes to investigating whether the subsidies actually caused the improvements, however, the study finds that the level of discount the school received did not matter.[30] The authors note that they cannot use control group methods, because almost all eligible schools in their survey took the E-Rate funds. They nevertheless conclude with a favorable review of the E-Rate.

Goolsbee and Guryan (2006) provide much more convincing evidence on the impact of the E-Rate program on schools, albeit only in California. The study uses detailed data on public schools, including students' achievement test scores, and their communities in California, as well as data from USAC on all E-Rate subsidy applications. The authors note several problems they face in determining the causal impact of the program on outcomes. Given that similar difficulties afflict most other studies of broadband-related programs, we discuss them in detail. First, Internet access in public schools was trending upward across the nation, and so an increase in access when the funding begins proves nothing by itself. To get around this problem, they use variation in the level of the subsidy for which the school qualifies as a natural experiment in the data. Thus, (loosely speaking) schools qualifying for lower subsidies serve as a control group for schools receiving higher subsidies.

The second problem is the non-random nature of this "experiment:" schools received discount levels based on the poverty level of their students, which may be correlated with unobserved factors determining the level of technology in the classroom. To address this issue, they use a regression discontinuity design, in which they exploit the fact that the E-Rate discounts are not a continuous sliding scale but instead take discrete jumps at certain poverty thresholds. So, for example, a school with 49 percent of its students on the free-lunch program qualifies for a 60 percent subsidy rate, while an otherwise similar school with 50 percent of its students on the free-lunch program qualifies for an 80 percent subsidy. The regression discontinuity method compares outcomes in otherwise similar schools falling within near distance to one of the subsidy thresholds. The authors control for the non-random assignment of subsidies in a standard regression

---

[30] See Appendix F of Puma, *et al*. (2002). Note that due to the difficulties in determining the causal impact of the discounts on improvements in Internet usage (as we discuss below when reviewing the study of Goolsbee and Guryan (2006)) failure of this variable to have a net observed influence in a basic regression may not be too meaningful.

framework, taking changes over time in Internet connections per classroom as the dependent variable to remove the influence of school-specific fixed effects.

The results of the study provide convincing evidence that the subsidies did lead schools to spend more on telecommunications technology. The price elasticity of demand, where quantity is measured in units of Internet-connected classrooms, is estimated to be between -0.4 and -1.1.[31] Furthermore, the study found that urban schools with large black and Hispanic populations had the greatest sensitivity to price reductions. Without the E-Rate program, the predicted classroom Internet connection rate is 40 percent, whereas with the program the connection rate is 66 percent, the difference between which they attribute to the impact of the program.

In the final part of their study, Goolsbee and Guryan (2006) turn to the impact of the program on its ultimate goal of advancing the educational mission of the schools. Here the answer is not as positive. An analysis of achievement test scores in math, reading, and science shows no evidence that the investment in broadband connectivity had any effect on outcomes. Similarly, there was measurable effect on the probability of taking advanced classes in high school, the rate of graduates going into the state's top-tier university system, or dropout rates.[32]

An initial screen when assessing the effectiveness of any program is whether the money was spent on its intended purpose. By any measure, fraud has been a problem with the E-Rate program (Jayakar, 2004). The FCC found $17.3 million in the USAC accounts that is potentially recoverable due to waste, fraud, and abuse of the E-Rate program for school and libraries, and states that "the E-Rate program has been a prime target for fraud perpetrators" (OIG, 2009, p.37). It is possible that if wasted funds were removed from the analyses of Puma, *et al*. (2002) and Goolsbee and Guryan (2006), these analyses might have estimated stronger impacts from E-Rate programs.

4.2 State Initiatives

There are many initiatives by the states to spread the usage of broadband, although many of the programs have not yet been thoroughly evaluated. The E-NC Authority, a program dedicated to expanding broadband coverage and Internet

---

[31] The regression-discontinuity approach returned even larger estimated impacts on technology adoption in the classroom, but also had larger standard errors (Goolsbee and Guryan, 2006).

[32] Ward (2005) also found that the E-Rate program failed to improve education outcomes in schools.

usage in North Carolina, is a state-level program that traces its roots to the state's Rural Internet Access Authority created in 2000.[33] The E-NC Authority focuses on rural and economically distressed urban areas. Funding comes from a variety of public and private sources. The program has undertaken various activities over the years, including offering reduced-cost computers to households. It currently offers grants for deploying last-mile broadband connections and connecting schools to the Internet and funds seven Business & Technology Telecenters (a form of CTC) in rural areas.

In a study funded by E-NC, (Wilson, 2008) chronicles the "amazing transformation" in North Carolina over the years 1999-2008 in areas such as computer ownership, Internet access, and Internet usage. For example, in 1999, only 57 percent of rural households with home computers had Internet access, while by 2004, this figure rose to about 90 percent, where it stayed for the next four years.[34] However, the report only looks at changes over time within the state, and there is no control group or other methodology employed that would allow causal analysis these E-NC programs.[35]

Another major initiative, Connected Nation, partners with a growing number of states to map broadband infrastructure and to stimulate demand for broadband. Connected Nation's goal is to promote broadband availability and to increase its use by facilitating public-private partnerships.[36] There are no formal, external analyses of Connected Nation programs to date, and so we examine its own broad claims of its success in Kentucky (ConnectKentucky) and Tennessee (Connected Tennessee).

ConnectKentucky is involved in many facets of digital inclusion, from providing computers to low-income families with children to broadband mapping with the goal of identifying opportunities for entry and areas where deployment should be encouraged. During the time of the ConnectKentucky program, broadband availability in the state increased by 53 percent from 2005 to 2007 and

---

[33] See http://www.e-nc.org.

[34] See Brodsky (2009) for a challenge of these figures.

[35] The report (when referring to gains in the fraction of rural households that use the Internet from home) states that "The e-NC Authority…should be proud that their work promoting computer access and Internet literacy has paid off in this unusually strong growth in rural counties." Unfortunately, this report appears not to provide the quantitative analyses necessary to permit this causal conclusion to be drawn.

[36] Connected Nation has programs in Kansas, Kentucky, Minnesota, North Carolina, Ohio, South Carolina, Tennessee, Texas, and West Virginia. Some of these currently focus nearly exclusively on broadband mapping. See http://connectednation.org/who_we_are/.

broadband use at home rose by 73 percent, the latter increase (from 22 percent in 2004 to 38 percent in early 2007) claimed to be more in percentage terms than any other state during the period (Mefford, 2007).[37] Computer ownership by households also increased by 20 percent (five times the national average). These statistics have been offered before Congress as evidence of the success of ConnectKentucky (Mefford, 2007), and the program takes credit for all these advances.[38]

Such a concerted effort on deploying and promoting the use of broadband no doubt had an impact in Kentucky. However, at least some of the growth in availability and usage would have occurred anyway. To mention just one other factor, Kentucky was also a top-ten recipient (in per capita terms) of federal E-Rate funding over the years 1998-2006 (Hudson, 2008), and the resulting increased availability of and exposure to the Internet surely prompted some of the growth in Internet use at home. With no control group provided within or without the state, there is no way to know how much of the growth in broadband adoption would have occurred in the absence of ConnectKentucky.

Furthermore, the particular statistics cited may be misleading to the unwary, because percentage increases in percentages can be difficult to interpret. When adoption rates are low, as they were in Kentucky in 2004, even modest numbers of new subscribers look large in percentage terms. Compare Kentucky's increase in broadband adoption rates with those from a wealthier and less rural state, Connecticut. For comparability we use statistics from the FCC and calculate the ratio of residential broadband lines to households.[39] By this measure, Kentucky increased from a penetration rate of 20 percent in 2005 to 43 percent in 2007, compared with an increase in Connecticut from 49 to 74 percent over the same years. Note that while the *percentage* increase in the penetration rate is higher in Kentucky, the increase in *the level* of the percentage points is about the

---

[37] Given that there are no yearly official statistics in the US on household broadband adoption rates, and that the FCC statistics on broadband lines for 2004 do not differentiate between residential and small business customers, it is unclear which statistics Connected Nation used for rates in other states.

[38] See http://www.connectkentucky.org/what_we_do/prescription_for_innovation.php.

[39] The former statistics are taken from the FCC's *High-Speed Services for Internet Access* semi-annual status reports (for mid-year figures), available at http://www.fcc.gov/wcb/iatd/comp.html, while the estimates of households in the states are from the US Census Bureau's American Community Survey (ACS) program (three-year estimates for 2005-2007). Census states that ACS three-year estimates represent the average characteristics over the period, and so we took the household figures to be for 2006. We then adjusted the household figures for other years by assuming that growth rates in the number of households mirrored that of population in each state.

same but a bit greater in Connecticut (where there was no Connected Nation or other demand-stimulus program).[40] This critique is not meant to imply that ConnectKentucky's programs were ineffective. Our point is merely that when penetration rates are low to begin with and broadband usage is generally increasing, it is likely that growth *rates* in adoption will be high regardless of targeted programs.[41]

Perhaps a better comparison state is Tennessee, which is more similar to Kentucky in terms of per-capita income but did not have a Connected Nation program in place during the 2005-2007 period.[42] Using comparable data as above, we find that Tennessee increased from a penetration rate of 26 percent in 2005 to 47 percent in 2007. Thus, whether looking at Kentucky, Connecticut, or Tennessee, broadband penetration appears to have increased by about the same number of percentage points (21 to 25).[43] Besides growth in broadband adoption rates, ConnectKentucky also includes among its metrics of success that home computer ownership grew by 20 percent in the state (ConnectKentucky, 2007). Computer ownership was 58 percent in 2003, 65 percent in 2005 and 72 percent by the second half of 2007.[44] These rates imply that about 135,000 households gained computers. Given that ConnectKentucky reports that its No Child Left Offline program distributed fewer than 2,000 computers to homes, it can be directly responsible for only a small portion of this growth (less than 1.5 percent of the

---

[40] The penetration rates in Kentucky increased by 23 percentage points and by 115 percent. The penetration rates in Connecticut increased by 25 percentage points and by 51 percent.

[41] There is a further technical reason why econometric studies usually choose to examine changes in rates rather than percentage changes in rates. When the rates pertain to units of observation (states, in this case) that have unobserved, time-invariant factors that may contaminate the analysis, taking the difference in rates over time (known as differencing the data, or more generally as using a fixed effects model) removes the influence of those factors and allows regression to isolate the causal impact of a policy. Taking percentage changes in the rates requires dividing the change in rates by the earlier rate, which re-introduces the very factors the change eliminated. To be precise, when the true model for a rate y for unit i at time t is $y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}$, where α_i is the influence of the contaminating factors and is correlated with the error term ε_{it}, then differencing the data produces the valid regression model $\Delta y_{it} = \beta \Delta x_{it} + u_{it}$ to consistently estimate the desired causal effect β of policy variable x_{it}. If instead the dependent variable is taken to be the percentage change in rate y, $\Delta y_{it}/y_{it-1}$, then α_i creeps back into the regression equation.

[42] The first action by Connected Tennessee, a release of broadband infrastructure maps for the state, was in the second half of 2007.

[43] Note that it is also possible that without intervention from ConnectKentucky's programs, performance in Kentucky may have lagged growth in other states. Thus, simply keeping pace with penetration growth in other states does not demonstrate ineffectiveness.

[44] The earliest statistic is from the US Census Bureau's Current Population Survey, October 2003 (see http://www.census.gov/population/socdemo/computer/2003/tab01B.xls), and the latter two statistics are from ConnectKentucky (2007).

growth, to be precise). Of course, it is possible that ConnectKentucky is indirectly responsible for more of the growth through its other programs.

ConnectKentucky employs basic control-group methodology in one of its publications (ConnectKentucky, 2008). Comparing counties that received computers through No Child Left Offline with other counties, ConnectKentucky (2008) reports that: computer ownership among low-income families in program counties grew nearly four times faster than low-income families in other counties; Internet adoption among low-income families in program counties grew more than ten times faster relative to low-income families in other areas; and broadband adoption among low-income families grew five times faster in program counties than in other counties.[45]

However, the comparison does not assure that the findings represent causal impacts for two reasons. First, the ConnectKentucky program (by design) chose the poorest, most underperforming counties in which to operate, and properly so, given its goals of extending digital inclusion. Thus, there is no notion of random assignment or a controlled experiment. Second, the comparisons are again given in terms of growth rates, which (as we have argued above) are always likely to be higher when starting from a lower baseline. It is thus impossible to know what the true impact of ConnectKentucky has been based solely on these reported figures.

4.3 Local Private Initiatives

There are dozens, if not hundreds, of local programs in the US with comprehensive goals that include spurring broadband adoption. We choose a few that have been subject to some degree of evaluation, and first discuss ZeroDivide, a philanthropic organization that seeks to increase digital inclusion in low-income and underserved areas of California with the goal of economic development. ZeroDivide recently funded five wireless broadband access projects in low-income, mostly non-white communities (Lee, 2009).[46] The projects were part of larger digital inclusion efforts in each community that sought to increase digital literacy, train community members in the use of technology, further household computer ownership by providing free or low-cost equipment, and develop community-

---

[45] Whether this last comparison is to *low-income* families in other counties or to overall rates in other counties is unclear.

[46] The communities were in Los Angeles, San Jose, San Diego, Sacramento, and San Francisco.

based web content. In addition to deploying Wi-Fi broadband networks, each project included a community technology center for training and computer access.

The projects provided broadband access to 451 homes, computers to 211 households, and training to 335 individuals. The total cost to ZeroDivide was $250,000, and the entire cost of the projects (including funding by partners) was more than twice that amount.[47] Unlike most project evaluations, Lee (2009) was able to measure Internet usage on the project's equipment, both by average daily number of users and amount of data downloaded. Less quantifiable were the claims that the projects increased educational attainment, promoted economic development, furthered the delivery of Government and Social Services, built community assets, empowered communities, and spurred civic action.

Our second local initiative is the Digital Inclusion Project (DIP). DIP is run by the Digital Inclusion Group (DIG), formerly Wireless Philadelphia. DIG partners with community organizations that distribute to low-income clients a "TechPak" that includes an ultra-portable laptop computer, high-speed Internet service, digital literacy training, local technical support, and content aimed at low-income households. The free computer is an important part of the project,[48] but each partnering community organization tied the computer into a larger program such as vocational training or parenting classes. While the partnership model allowed DIG to extend its reach into more communities than it had the resources to do on its own, the model also ran into difficulties due to the uneven technological capabilities of the partners, some of whom needed more digital training themselves (OMG, 2008). The partnership collectively distributed 762 digital bundles by the time of the review, reaching 77 percent of their distribution goals.

The preliminary evaluation of the DIP by OMG (2008) was conducted after only three months of its operation, and so few metrics regarding its success were available. Some difficulties were noted. Due to technical problems with the Wi-Fi network Earth Link set up, many clients did not receive strong or consistent signals in their homes, which negated some of the value of the free hardware and

---

[47] The sum of the stated funds contributed by all partners listed in Lee (2009) is $542,900, but many contributions and much of the labor cost do not have dollar values assigned. Thus, the available figures only imply that the cost per household impacted was at least $1,200, but it is impossible to know how much more the cost may have been.

[48] The justification given in the evaluation for the importance of the free computer is presumably true, but weakly documented. The report states that "interviewees all agree that there is a large demand for free, low-cost, and/or discounted hardware among underserved populations" and that even among residents with income above the threshold, "there is client demand for new computers at discounted rates" (OMG, 2008, p.5).

software. The need for strong technical support to offer to clients also became apparent, particularly after Earth Link pulled out of the partnership in 2008. The evaluation also finds that the number of TechPaks distributed was not the best predictor of overall Internet use by DIP clients. More important factors were whether the free computer was integrated into the training sessions with the clients, whether the free bundle was used to incentivize the training, and whether the partnering organizations followed up with the clients. Client use of the technology was surveyed, but no specific metrics of enhanced digital inclusion are employed in the preliminary evaluation and no control group was included in the analysis.

Lastly, we discuss One Economy's Digital Communities programs for low-income communities. One Economy is funded by a private foundation to provide families with low-cost computers and free Internet access (some wireless, some fixed access, and not all broadband) in the home (Michalchik, *et al.*, 2006). In addition to the equipment and service, One Economy also trains youth as "Digital Connectors" to help set-up and troubleshoot the computers on an ongoing basis. An important part of the Digital Community concept is the Beehive, an online portal to information about finances, health, school, jobs, childcare, and other topics of local interest to the community. Thus, while the subsidized computer is the "foundation" of the efforts (Michalchik, *et al.*, 2006), the program also seeks to lower barriers related to the price of Internet access, lack of relevant content online, and lack of digital literacy and computer skills.

Michalchik, *et al.* (2006) evaluate two Digital Communities set up by One Economy (one in San Jose, California and another in the Little Havana neighborhood of Miami, Florida). The research group surveyed participants in the program soon after joining and again after about a year, and also conducted focus groups. There was no explicit control group for the studied communities, but comparisons were made to low-income usage across the nation, as determined from the Pew Internet surveys.[49] The main finding of the study is that the program led to large increases in Internet usage at home for participants. After a year in the program, 82 to 86 percent of participants reported using the Internet at home, compared to only 46 percent of low-income households nationally. Of more importance for present purposes, 63 percent of the participants in San Jose had broadband access at home, 29 percent of those in Miami had broadband, but

[49] With program participation in each location limited to 100 participants, there likely was excess demand for inclusion in the project. A useful control group might have been drawn from applicants who were not given computers and Internet access, since they were presumably of similar motivation to get connected (an important unobserved factor determining Internet adoption) and of similar demographic characteristics to those families that were accepted.

only 17 percent of the national low-income sample did. The evaluation does not report *increases* in Internet or broadband use at home, but (given the nature of the program) it is reasonable to assume that usage rates were near zero among participants before they joined the program. Another encouraging result is that of the 92 percent in each city that had Internet connectivity at home one and a half years after the program started, only about one third were still using free wireless access provided by One Economy. Thus, many households apparently had become paying Internet subscribers.[50]

4.4 Local Municipal Initiatives

One of the few subsidy policies with independent, peer-reviewed external evaluation is the LaGrange Internet TV (LITV) program in Georgia (Youtie, Shapira, and Laudeman, 2007). The municipal LITV program gave residents a free package consisting of a wireless keyboard and an intelligent TV set-top box, which (using the cable TV network) allowed users to use e-mail and browse the Internet. The setup enabled Internet access,[51] but of an inferior quality, since the only monitor was the television, the terminal had no storage capacity, and users could not download files, open attachments, run browser plug-ins, or print. On the plus side, the system was simpler to use than a full computer setup, and for no additional cost beyond the $8 subscription fee for basic cable, a household in LaGrange (a small town of about 30,000 residents) could access the Internet.

Despite the marginal price of zero for the package, a full 40 percent of eligible households never tried LITV at all. Only half of these households had another form of Internet connection. Non-adopting households came from across the income and education spectrum. Thus, a free, easy-to-use system did not automatically attract all low-income, less-educated households. Youtie, Shapira, and Laudeman (2007) conclude from their basic quantitative analysis that lowering the price alone, in the absence of other initiatives to stimulate demand such as education and training, is insufficient to accomplish policy goals such as increasing residents' ICT-related skills. The authors of the study are not able to isolate the relative importance of adoption drivers such as the low-quality experience and the technical problems that plagued the project. However, the message from the experience underscores an important lesson for policymakers: subsidies alone may not be enough to reach all targeted households.

---

[50] It is unclear from the evaluation exactly how many households migrated to fully paid subscriptions, since not all were initially receiving access through the One Economy wireless access points.

[51] Technically, the service was not broadband, but it was twice as fast as dial-up.

4.5 Programs Not Primarily Targeting Broadband Adoption

Federal, state, and local governments have proposed or implemented a variety of programs tangentially related to promoting broadband demand. Two such types of programs are those that provide computers directly to households, and those that provide computers to publicly accessible sites. Studies assert that programs that give computers to households succeed in so increasing computer usage (Andrews, Jannasch-Pennell, and DiGangi, 2004).

One example of such a program is the Computers for Youth project. Computers for Youth partners with schools in low-income areas, giving children refurbished desktop computers, educational and general software, reduced price Internet access,[52] training, and technical support.[53] The first-year outcomes of the program, focusing on how computer use at home affects engagement and performance in school, are evaluated in Tsikalas, Lee, and Newkirk (2007). Students' home computer and Internet use explained 14 percent of the variance in standardized test scores in math, beyond the (larger) amount of variance explained by the previous year's score. An interesting finding from the Computers for Youth program is that even with the free computer and Internet access, thirty percent of the children reported that they never accessed the Internet from home (Tsikalas, Lee, and Newkirk, 2007). Whether this is due to lack of Internet-specific training or lack of motivation or interest is not investigated. Nevertheless, the program demonstrates once again that merely pulling down the barriers associated with cost and computer access does not necessarily, by itself, lead to full digital inclusion.

Community access to computers is often accomplished through CTCs. Pollio and Truscott (2004) examine the Grace Hill Settlement House, which operates a CTC funded under NTIA's Technology Opportunities Program. The CTC provided computer and Internet training classes for the parents of children in Grace Hill's Head Start program, with the goal of "e-involvement." Pollio and Truscott (2004) found that English-speaking children showed developmental improvement in the Head Start program when their parents received the training. In addition, Internet usage by participants increased by 59 points.[54]

---

[52] Students were given eight hours of Internet access free, and then charged $10/month.

[53] A description of the program is available at http://www.cfy.org/take-it-home.php.

[54] Given that only three months passed between the surveys, it is probably safe to presume that nonparticipants in the control group would not have increased their digital literacy much, and so the lack of a control group in this instance may not be of much import. Of greater importance,

For an excellent and comprehensive review covering many hundreds of other digital literacy programs, see Hilding-Hamann, *et al.* (2009a, b), who identify best practices and common themes among the various digital inclusion initiatives. The authors also review the empirical findings on outcomes of a panoply of projects across OECD countries, and conclude there is a paucity of convincing demonstrations of outcomes and impacts.

5 Synthesis and Conclusion

5.1 What Works Best

While our review of program evaluations revealed a disappointing dearth of studies that quantify the causal impact of programs in a convincing manner, a few general conclusions on what makes a program successful can be drawn from the literature. Given the multiplicity of barriers to broadband adoption, a successful program must tackle many goals. A program should *motivate* non-users to adopt, make broadband *affordable*, employ *content* in the training that relates to everyday life or the use of public services, and focus on the *accessibility and usability* of broadband and online services (EC DGISM, 2008). In other words, encouraging broadband adoption is only part of a larger digital literacy effort, and programs work when they make non-users want to connect, make the Internet cheaper and easier to use, and adjust to users' preferences.

The scope of programs ranges from national initiatives down to grassroots efforts in local communities. There are advantages and disadvantages to each end of the spectrum. One of the difficulties with large federal programs concerns oversight. Programs can be cost-effective only if they are effectively overseen and if those receiving the funding are held accountable for its disposition. When the sums of money are large and the provider of funding is far removed from the local projects that are the ultimate recipients, the incentive for waste and abuse of funds is heightened.[55]

Local efforts have many commendable advantages. When local governments or community organizations are involved in overcoming broadband adoption gaps, they typically begin with a more complete knowledge of what the barri-

---

we suspect, is that participants were self-selected: the treatment group consists of parents motivated enough to agree to be in the program.

[55] Of course, the avoidance of illegal use of the taxpayers' money is only a necessary condition for the economic efficiency. Full efficiency requires accomplishing a program's goals at minimum cost and directing funding to programs where the next dollar will have the highest demonstrable impact.

ers are in the community. National policies may tend toward one-size-fits-all solutions handed down from above. For example, if the E-Rate program's provision of access had been coupled with programs to increase the digital skills of the teachers themselves, and to train them in the pedagogical uses of the Internet, perhaps outcomes would have been better. While not qualifying as waste in the legal sense, it is surely economically inefficient to install telecommunications equipment in a school where teachers do not know how to integrate it into their teaching.

Local organizations also may be more effective at ensuring that programs are actually utilized by the intended recipients. One of the difficulties encountered by the California Teleconnect Fund, a government-run subsidy program for schools, libraries, and hospitals administered at the state level, is that many targeted institutions had never even heard of the program after it had been operating for almost a decade (CPUC, 2005). Contrast this with the Digital Inclusion Project's approach to reaching the disconnected by partnering with grassroots organizations that were already involved with the targeted communities in Philadelphia (OMG, 2008).

The disadvantages of purely local efforts have to do with the limited capabilities of such organizations to collect data and set up programs in such a way that they can be evaluated effectively. This may be where direction and resources from the larger funding source (national or state-level, for example) can provide valuable guidance and assistance. For instance, part of the funding can be provided for the local organization to partner with a university or other external, independent policy research group to assist in designing policies with quantitative program evaluation in mind, and to perform the actual analysis.

5.2 What is Missing in the Literature

5.2.1 Cost-Benefit Analysis (CBA)

One of the most glaring omissions from most program evaluations we reviewed was any rigorous attempt to assess how the costs of the project or initiative compared to the benefits. Benefits may be difficult to quantify, but no better alternative to CBA has been proposed to efficiently allocate society's resources to meet the many policy goals we have in the US today. Even setting aside the benefits, the cost-side analysis of most project evaluations we reviewed is largely deficient. Many evaluations look only at outcomes without considering whether (or assuming that) the benefits justify the costs (which remain uncounted).

Even when evaluators attempt to examine the cost side of a program, they often disregard elements of social cost not directly funded by "their" organization. In other words, many program evaluations take a narrow rather than a social view of costs.[56] A common unaccounted cost of a project is the opportunity cost of paid or volunteer labor. For example, the Digital Impact Group does not include overhead or staffing cost in its estimates of the cost of their "TechPak" (OMG, 2009). Some evaluations explicitly claimed that CBA was impossible due to the involvement of volunteers. For example, Lee (2009) notes that many committed staff members of projects funded by ZeroDivide were motivated to provide unpaid hours of labor to help the projects succeed, and so the true social cost of the program is greater than its accounting costs.

Similar undercounting of labor appears in official federal project evaluations. For example, consider an evaluation sponsored by the National Telecommunications and Information Agency (NTIA) of a NETmobile project funded through its Telecommunications and Information Infrastructure Assistance Program. The project had about $345,000 in itemized project costs (federal and other), but substantial amounts of time donated by private sector employees to the project are not valued in the report because the hours were not charged to the grant (NTIA, 1998).[57]

There is also much room for improvement in the majority of evaluations that do not attempt to quantify any benefits. Statements that advantages and benefits of a program are "invaluable," "profound," or "priceless"—all of which we ran across in our review of program evaluations—are of little use in guiding policy makers toward sound decisions.

While appropriate CBA is essential for program evaluation, it is beyond the scope of this review to begin CBA of specific programs that may be implemented under the National Broadband Plan. It would be instructive to draw lessons from careful and thorough CBA of other governmental programs aimed at

---

[56] The counterpart to the narrow view on the benefit side are the evaluations we reviewed that justify a state or local project's success by the amount of federal grant money it receives, ignoring that from the social point of view, such transfers are socially neutral at best and deadweight-loss creating at worst (due to inefficient funding mechanisms).

[57] The project evaluation states that 4,234 individuals were "served" by the NETmobile (a mobile computer, Internet access, and teaching lab). At the stated project cost, the average cost per individual is only about $80, which sounds very cost-effective until (reading on in the report) it appears that some of those "served" were schoolchildren who spent only 25 minutes in the NETmobile. The report also notes that the NETmobile had its hubcaps stolen in Washington, D.C. (it is unclear whether the replacement cost of the hubcaps was included in the project cost).

technology diffusion. However, per Stoneman and Diederen (1994), as late as the 1990's there were no evaluations of whether actual technology diffusion policies pass economic CBA tests, and we are unaware of complete analyses of programs aimed at encouraging the diffusion of consumer technologies since that time. Nevertheless, the theoretical literature on technology diffusion policy suggests when a program might have the greatest net social benefits (in addition to the factors for program success discussed above). Work by Stoneman and David (1986) suggests that subsidies for the use of technology may be more beneficial socially when the good is supplied by imperfectly competitive markets, for then it is less likely that the effective price to the consumer is driven below the marginal cost of provision. On the other hand, when policy takes the form of providing information about the technology (which, in the current context, also would include training in the use of the broadband), intervention may best be directed toward competitive markets. In such markets, where free-riding concerns make the private provision of information less profitable, government efforts are less likely to crowd out private efforts (Stoneman and David, 1986). This suggests, very broadly, that policies targeting the price of broadband may be best deployed in geographic regions where competition in the provision of broadband is less robust, and using other demand stimulus methods in markets where competition is stronger.

5.2.2 Rigorous Program Evaluation

Heckman, LaLonde, and Smith (1999), in the context of evaluating job training programs, stress the importance of focusing on program outcomes rather than program completion, collecting data that will enable an evaluation, and using the appropriate economic model.[58] These three elements are required to conduct an evaluation of a program that is useful to policymakers and others concerned about the efficient allocation of resources to meet social goals. We touch on each element in turn.

Confusing the execution of a program with the attainment of its ultimate goals is an easy pitfall for evaluators to fall into, and formal program reviews too often limit their analysis to proximate goals. As one review noted, "…many grant recipients tended to focus on whether an initiative had been successfully executed, as opposed to whether the initiative had helped to address a broader community

[58] The work cited by Heckman, LaLonde, and Smith (1999) includes many serious and credible attempts to evaluate the benefits of job programs and on occasion to combine the results with CBA (although CBA does not appear fruitful for job training programs in general – see LaLonde (1995)).

problem" (Frechtling, et al. 1999). The fact that it is easier to measure successful program execution partially explains the lack of focus on whether a program meets its larger goals. However, another part of the explanation may be that it is much easier for a program to be correctly completed than it is for it to have real impacts on participants. Therefore, for those wishing to demonstrate the "success" of a program (particularly if further funding is contingent upon the analysis), there may be little incentive to address the more difficult questions of ultimate impacts.

Without the right data, it can be impossible to evaluate whether an initiative met its goals. Unless the funding agency explicitly requires recipients of funds to collect appropriate data, it should not expect useful data to be gathered.[59] The effort to gather appropriate data must begin at the inception of the project, for it might determine who should be chosen to receive funding in the first place. Take the Digital Inclusion Project as an example: OMG (2008, p. iii) reports that while the sponsors wanted to track client outcomes, project partners were neither selected for their abilities to do so nor were they so trained. The recommendations for setting up the Digital Excellence project in Chicago (ACCDD, 2007) provide a good model. The report encourages the project to partner with a university to conduct baseline surveys in affected and unaffected neighborhoods. Even when these tasks are outsourced, however, the partners must be brought into the project before the intervention begins, to be able to collect baseline data.

The data gathering effort also must be integrated with the program participation guidelines. For example, one factor limiting the analysis of the Digital Inclusion Project is that the community partners did not develop agreements with clients to stay in contact for longitudinal data collection (OMG, 2008). When various such community partners are involved, it becomes all the more important that the entity funding the projects establish a consistent set of metrics that recipient organizations must report. Lee (2009) notes in her preliminary evaluation of five ZeroDivide digital inclusion projects in California that grantees were not required to report a standard set of data on activities and outcomes, so that systematic evaluation of labor costs, for example, was impossible. Furthermore, Lee (2009) also found that data were missing on all basic aspects of the projects, including network usage, training, demographics of the participants, adoption rates, job creation, which made assessing the projects difficult.

[59] For example, Frechtling, et al. (1999, p.VI) note that "few of the 1994 and 1995 [TOP] projects…invested the staff or financial resources needed to collect…data that could be used to assess real progress toward their community change goals."

Finally, the best data in the world are of little use unless program evaluators use appropriate methods of analysis. Appropriate statistical methods must be used to assess whether the program resulted in its intended external results for its beneficiaries and the broader public. It may be appropriate to draw lessons from the literature on empirical studies of job training programs and their effects on labor market outcomes, which are among the strongest examples of program evaluations that we have in economics (see, e.g., LaLonde (1995) and the many studies cited in Heckman, LaLonde, and Smith (1999)). A primary focus of this literature is on evaluating the appropriateness (and perils) of various methodologies used to measure program success (Heckman and Smith, 1998; Heckman, LaLonde, and Smith, 1999). There is no one best econometric method that fits all cases, and often researchers use multiple methods to be able to draw robust conclusions.[60] However, when a control or comparison group is available (as it will be if the program is designed well), the *differences in differences* (D-D) technique, a staple of the modern econometric approach to program evaluation, often works well.[61] The best succinct recommendation for project overseers is to collaborate with an academic or other quantitative analysis group with experience in *causal* econometric policy evaluation.

Sometimes the non-experimental nature of policies requires the use of more sophisticated econometric methods for analysis. For example, Kandilov and Renkow (2009) use both differences-in-differences and propensity score techniques[62] to find that USDA broadband loans had no impact on economic development. However, even the most basic use of econometrics would be a step forward in most evaluations. Far too many evaluations use "soft" analytical methods from the social sciences to come to "hard" causal conclusions. Too often, case study evaluation methods consist of little more than reporting results of focus

[60] For example, Goolsbee and Guryan (2006) employ both regression-discontinuity design and multiple regression techniques in their study of the E-Rate program.

[61] D-D removes the impact of all factors that are specific to the individual but do not change over time, and also the impact of all factors that are year specific but do not change across individuals in the sample (Meyer, 1995). Thus, D-D can identify trends in broadband usage for program participants that are net of trends affecting participants and non-participants alike. Controlling for overall trends in broadband adopting is important, given that adoption is steadily rising in the US.

[62] Propensity scores have been used to reduce bias in studies where the individuals (or other units of observation) choosing to participate in a program differ from those who do not. In studies such as these, the participants and the control group may differ markedly with respect to observed characteristics, and such differences can lead to biased estimates of a program's effects. The propensity score is the conditional probability of participating given the individual's characteristics, which is used to match individuals in the program participation group with those in the control group, thus matching like to like and reducing bias.

group discussions. While qualitative methodology may help the program fine-tune its methods and approaches to achieving its goals, such analyses are nearly useless for answering questions about the cost effectiveness and ultimate benefits of the program.

Regardless of how sophisticated is the econometric method, the core idea of establishing the causal impact of a program is to compare observed outcomes with an estimate of the counterfactual: what outcomes would have been in the absence of the program. Econometric techniques differ in the way they identify that causal impact, but the basic idea is the same in all methods. In fact, good methods for policy analysis are all variations on the theme of drawing causal conclusions that are immune to the Fallacy of False Cause we noted in the introduction. Note that there may be few internal incentives for a program to evaluate rigorously the causal effects of its policies. Given that broadband adoption is generally increasing across all groups in the US,[63] it is easy to "show" that a program "led to" more adoption by noting that adoption rose after a program was instituted. Netting out what would have happened anyway, in the absence of the program, only serves to diminish the apparent impact of the program.

It is interesting to note that the FCC's National Broadband Plan does not appear to be focused on ascertaining causal impacts in this way. Although the Notice of Inquiry for the National Broadband Plan addressed this issue squarely by asking for comment "on how progress can be measured relative to progress that would have occurred in the absence of any program to better understand the impact of the program" (FCC, 2009, p. 11), the Plan itself contains no such recommendation. In fact, the Plan appears to be predisposed toward confirming its own success, with statements such as "[i]f this broadband plan is effective, we will see rapid progress in terms of increased adoption…." Given the progress of broadband adoption across every demographic group over the past decade (albeit at differing rates among groups), it is difficult to imagine circumstances under which continued progress would not occur even absent the Plan.[64]

---

[63] Even in the recent tough economic times for many households, fewer than one in ten canceled or cut back their Internet service (Horrigan, 2009b). In fact, the same survey shows that households cling to their online access more than they do to wired or wireless phone or cable television services.

[64] The Plan also explicitly puts evaluation in the back seat of the policy car: "evaluation is not an excuse for paralysis. Actions and their results matter most to capturing the opportunities broadband presents" (Ch. 17 of the Plan).

6 Final Thoughts

In our review of programs that seek to accomplish the goal of stimulating demand for broadband Internet access, we have focused narrowly on the question of "what works?" We did not begin, as many such studies do, with the larger question of why broadband adoption should be stimulated, and we do not intend to take up the question here. However, we note that careful, convincing quantitative studies on the benefits provided by broadband for individual users are just as rare—if not even scarcer—than those on program effectiveness. To quote Strover (2009, p.213): "[T]here is scant evidence that telecommunications can transform lives in the absence of change in other structural features, such as household income and education levels."

The National Broadband Plan calls for the establishment of a "broadband data depository" to facilitate research on program effectiveness.[65] While the details of the depository remain in the air, we may shortly be entering a new era of research possibilities regarding broadband usage and policy. We hope that our review herein, highlighting how slim the literature actually is, serves as a call to arms to stimulate renewed effort and attention toward measuring and quantifying actual impacts of programs and of broadband itself on the American people.

7 References

Advisory Council on Closing the Digital Divide (ACCDD) (2007), *The City that Networks: Transforming Society and Economy Through Digital Excellence*, Chicago, May.

Aizu, Izumi (2002), "A Comparative Study of Broadband in Asia: Deployment and Policy," *Asia Network Research Discussion Paper*, September 29, available at http://www.anr.org/web/html/output/2002/bbasia0929.pdf.

Andrews, Sandra Sutton, Angel Jannasch-Pennell, and Samuel A. DiGangi (2004), *The Digital Divide: Focused Research Results On Peer Mentoring, Scalability and Occupational Self Efficacy In a Home-Based Technology Integration Program.* Paper presented at 27th proceedings of the Association for Educational Communications and Technology, Chicago, October 19-23, available at http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED485039.

[65] See Recommendation 17.2 in the Plan.

Aron, Debra J. and David Burnstein (2003), "Broadband Adoption in the United States: An Empirical Analysis," in Shampine, *et al*. (Eds.), *Down to the wire: Studies in the diffusion and regulation of telecommunications technologies*, 119 -138, Nova Science Publishers, Haupaugge, NY.

Belloc, Filippo, Antonio Nicita, Maria Alessandra Rossi (2009), "Whither Broadband Policy? In Search of Selective Intervention," working paper, Università degli Studi di Siena, Quaderni del Dipartimento di Economia Politica, August, available at http://www.econ-pol.unisi.it/quaderni/567.pdf.

Brodsky, Art (2009), "Connected Nation Takes Aim at Stimulus Broadband Mapping; Rural Areas Could Be Hurt," blog post dated February 17, available at http://www.publicknowledge.org/node/1998.

California Public Utilities Commission (CPUC) (2005), *Broadband Deployment in California*, May 5, available at http://www.cpuc.ca.gov/PUC/Telco/generalInfo/0505_broadbandreport.htm.

Cardona, Mélisande, Anton Schwarz, B. Burcin Yurtoglu, and Christine Zulehner (2007), "Demand Estimation and Market Definition for Broadband Internet Services," working paper, available at http://ssrn.com/abstract=1081261.

Cava-Ferreruela, Inmaculada, and Antonio Alabau-Muñoz (2006), "Broadband Policy Assessment: A Cross-National Empirical Analysis," *Telecommunications Policy* 30 (2006) 445–463.

Choudrie, Jyoti and Heegin Lee (2004), "Broadband Development in South Korea: Institutional and Cultural Factors," *European Journal of Information Systems* 13:103-114.

Compaine, B. and Weinraub, M. (1997), "Universal Access to Online Services: An Examination of the Issue," *Telecommunications Policy*, Vol. 21, pp. 15-33.

Connected Nation (2008), *Consumer Insights to America's Broadband Challenge: A Research Series from Connected Nation, Inc.* October 13, available at http://connectednation.com/research/publications/Consumer%20Insights%20 Broadband%20Challenge_2008%2010%2013.pdf.

ConnectKentucky (2007), *2007 Kentucky Technology Trends: Results of the 2007 ConnectKentucky Residential Survey*, available at http://www.connectkentucky.org/_documents/2007KentuckyTechnology Trends_residential_6-11-08.pdf.

ConnectKentucky (2008), *Connected: ConnectKentucky Quarterly*, Winter.

Crandall, Robert, J. Gregory Sidak, and Hal Singer (2002), "The Empirical Case Against Asymmetric Regulation of Broadband Internet Access." *Berkeley Law and Technology Journal* 17(1): 953-987.

Distaso, Walter, Paolo Lupi, and Fabio Manenti (2006), "Platform Competition and Broadband Uptake: Theory and Empirical Evidence from the European Union," *Information Economics and Policy* 18: 87-106.

Dutz, Mark, Jonathan Orszag, and Robert Willig (2009). "The Substantial Consumer Benefits of Broadband Connectivity for US Households." Commissioned by the Internet Innovation Alliance, available at http://internetinnovation.org/files/special-reports/CONSUMER_BENEFITS_OF_BROADBAND.pdf

European Commission, DG Information Society and Media (EC DGISM) (2008), *Digital Literacy Report: a review for the i2010 e-inclusion Initiative*¸ European Commission Staff Working Document, available at http://ec.europa.eu/information_society/eeurope/i2010/docs/digital_literacy/digital_literacy_review.pdf.

Federal Communications Commission (FCC) (2009), *Notice of Inquiry in the Matter of A National Broadband Plan for Our Future*, April 8, FCC 09-31, available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-09-31A1.pdf.

Federal Communications Commission (FCC) (2010), *Connecting America: The National Broadband Plan*, available at http://www.broadband.gov/download-plan/.

Flamm, Kenneth and Anindya Chaudhuri (2007), "An Analysis of the Determinants of Broadband Access," *Telecommunications Policy* 31: 312–326.

Ford, George S., Thomas M. Koutsky, and Lawrence Spiwak (2008), "The Broadband Efficiency Index: What Really Drives Broadband Adoption Across the OECD?" Phoenix Center Policy Paper Number 33.

Frechtling, Joy, John Lockwood, Gary Silverstein, Laurie Somers, Paul Tuss (1999), *Evaluation of the Telecommunications and Information Infrastructure Assistance Program for the 1994 and 1995 Grant Years*, Report by Westat prepared for US Department of Commerce, National Telecommunications and Information Administration, February, available at http://www.ntia.doc.gov/top/research/EvaluationReport/exsum2.pdf.

General Accountability Office (GAO) (2006), *Broadband Deployment Is Extensive throughout the United States, but It Is Difficult to Assess the Extent of Deployment Gaps in Rural Areas*, GAO-06-426, May.

Gillett, Sharon E, William H. Lehr, Carlos Osorio (2004), "Local Government Broadband Initiatives," *Telecommunications Policy* 28 (2004) 537–558.

Gillett, Sharon E., William H. Lehr, Carlos A. Osorio, and Marvin A. Sirbu (2006), *Measuring Broadband's Economic Impact*, report prepared for the Economic Development Administration, US Department of Commerce, February 28.

Goolsbee, Austan (2006), "The Value of Broadband and the Deadweight Loss of Taxing New Technology," *Contributions to Economic Analysis & Policy* 5(1), Article 8.

Goolsbee, Austan and Jonathan Guryan (2006), "The Impact of Internet Subsidies in Public Schools," *Review of Economics and Statistics* 88(2): 336–347.

Goolsbee, Austan and Peter J. Klenow (2002), "Evidence on Learning and Network Externalities in the Diffusion of Home Computers," *The Journal of Law and Economics* 45: 317–343.

Greenstein, Shane and Ryan McDevitt (2009), "The Broadband Bonus: Accounting for Broadband Internet's Impact on U.S. GDP," National Bureau of Economic Research, Inc, NBER Working Papers: 14758.

Hauge, Janice A. and James E. Prieger (2009), "Demand-Side Programs to Stimulate Adoption of Broadband: What Works?" Available at SSRN: http://ssrn.com/abstract=1492342.

Hauge, Janice A., Eric P. Chiang and Mark A. Jamison (2009), "Whose call is it? Targeting universal service to low-income households' telecommunications preferences," *Telecommunications Policy* 33(3-4): 129-145.

Heckman, James J., Robert J. Lalonde, and Jeffrey A. Smith (1999), "The economics and econometrics of active labor market programs," in *Handbook of Labor Economics*, *Vol 3* (pp.1865-2097). Amsterdam: Elsevier B.V.

Heckman, James J. and Jeffrey A. Smith, Jeffrey (1998), "Evaluating the Welfare State," in *Econometrics and Economic Theory in the Twentieth Century: The Ragnar Frisch Centennial Symposium* (pp. 241-318). Cambridge: Cambridge University Press.

Hilding-Hamann, Knud Erik, Morten Meyerhoff Nielsen, and Kristian Pedersen (2009a), *Supporting Digital Literacy: Public Policies and Stakeholder Initiatives*, *Topic Report 1, Final Report.* Danish Technological Institute, Centre for Policy and Business Analysis, February, available at http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/dl_topic_report_1.pdf.

Hilding-Hamann, Knud Erik, Morten Meyerhoff Nielsen, Jan Overgaard, and Kristian Pedersen (2009b), *Supporting Digital Literacy: Analysis of Good Practice Initiatives*, *Topic Report 3, Final Report.* Danish Technological Institute, Centre for Policy and Business Analysis, February, available at http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/dl_topic_report_3.pdf.

Horrigan, John (2009a), "Obama's Online Opportunities II: If you Build it, Will They Log On?" Pew Internet & American Life Project, January, available at http://www.pewinternet.org/~/media//Files/Reports/2009/PIP_Broadband%20 Barriers.pdf.

Horrigan, John (2009b), "*Home Broadband Adoption 2009: Broadband Adoption Increases, but Monthly Prices Do Too*," Pew Internet & American Life Project, June, available at http://www.pewinternet.org/~/media//Files/Reports/2009/Home-Broadband-Adoption-2009.pdf.

Horrigan, John (2010), *Broadband Adoption and Use in America,* Federal Communications Commission Omnibus Broadband Initiative Working Paper Series No. 1, available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296442A1.pdf.

Hu, Wei-Min and James E. Prieger (2009), "The Empirics of the Digital Divide: Can Duration Analysis Help?" *Handbook of Research on Overcoming Digital Divides: Constructing an Equitable and Competitive Information Society*, Enrico Ferro, *et al*. (Eds.), Hershey, PA: IGI Global, July.

Hudson, Heather E. (2004), "Universal Access: What Have We Learned from the E-rate?" *Telecommunications Policy* 28(3-4):309-321.

Hudson, Heather E. (2008), "The Future of the E-Rate," Ch. 13 in *...and Communications for All: A Policy Agenda for the New Administration*, A.M. Schejter (Ed.), Lanham: Lexington Books.

Ida, Michiru and Yoshiyuki Kuroda (2006), "Discrete Choice Analysis of Demand for Broadband in Japan," *Journal of Regulatory Economics* 29(1): 5-22.

Intel Corporation (2009), *Reply Comments*, filed in the matter of A National Broadband Plan for Our Future, GN Docket No. 09-51, before the Federal Communications Commission, available at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=7019917580.

Jayakar, Krishna P. (2004), "Reforming the E-Rate," *Info* 6(1):37-51.

Kandilov, Ivan T. and Mitch Renkow (2009), "Infrastructure Investment and Rural Economic Development: An Evaluation of USDA's Broadband Loan Program," North Carolina State University Dept. of Agricultural and Resource Economics Working Paper, available at http://www4.ncsu.edu/unity/lockers/users/v/vukina/AG_ECO_Workshop/Fall_2009/Kandilov_Renkow.pdf.

King, John Leslie, Vijay Gurbaxani, Kenneth L. Kraemer, F. Warren McFarlan, K. S. Raman, C. S., Yap (1994), "Institutional Factors in Information Technology Innovation," *Information Systems Research* 5(2):139-169.

Korea Network Information Center (KANIC) (2002), *A Survey on the Number of Internet Users and Internet Behavior in Korea (Summary)*, July, available at http://isis.nida.or.kr/eng/board/index.jsp?pageId=040100&bbsId=10&itemId=25&pageIndex=8.

Krueger, Alan (2003), "The Digital Divide in Educating African-American Students and Workers," in Cecilia Conrad (Ed.), *Building Skills for Black Workers*. New York: University Press of America, pp. 51-76.

LaLonde, Robert J. (1995), "The Promise of Public Sector-Sponsored Training Programs," *The Journal of Economic Perspectives* 9(2): 149-168.

Lee, Heejin, Robert M. O'Keefe, and Kyounglim Yun (2003), "The Growth of Broadband and Electronic Commerce in South Korea: Contributing Factors," *The Information Society*, 19:81-93.

Lee, Sangwon, and Justin Brown (2008), "Examining Broadband Adoption Factors: an Empirical Analysis Between Countries," *Info* 10(1):25-39.

Lee, Tina (2009), *ZeroDivide Case Study: Community Wi-Fi Study*, available at http://www.zerodivide.org/sites/default/files/ZeroDivide_Community_WiFi.pdf.

Mefford, Brian R. (2007), "Broadband Mapping and Data Collection," Prepared Testimony, before the US House of Representatives Committee on Energy and Commerce, Subcommittee on Telecommunications and the Internet, May 17, available at http://connectednation.com/in_the_news/testimonies_and_presentations/Mefford%20Brian_House%20Committee%20on%20Energy%20and%20Commerce_2007%2005%2017.pdf.

Meyer, Bruce D. (1995), "Natural and Quasi-Experiments in Economics," *Journal of Business & Economic Statistics*, 13(2):151-161.

Michalchik, Vera, Sara Carriere, Deborah Kim Emery, Larry Gallagher, Ann House, Andres Molina, Lynne Peck Theis, and William R. Penuel (2006), *One Economy Digital Communities: Transforming Lives for Low-Income Americans*, Center for Technology in Learning, available at http://www.one-economy.com/sites/all/files/SRI-Digital-Communities-Miami-SJ-Eval-2-06.pdf.

National Telecommunications & Information Administration (NTIA), US Department of Commerce (1998), *Evaluation of the Telecommunications and Information Infrastructure Assistance Program: Case Study Report: Project NETmobile*, available at http://www.ntia.doc.gov/TOP/research/EvaluationReport/case_studies/edinburg-tx.PDF.

Office of Inspector General (OIG), Federal Communications Commission, (2009), *Semiannual Report to Congress: October 1, 2008—March 31, 2009*, available at http://www.fcc.gov/oig/OIG_SAR_033109.pdf.

Office of Technology Policy (OTP), US Dept. of Commerce (2002), *Understanding Broadband Demand: A Review of Critical Issues*, September 23, available at http://purl.access.gpo.gov/GPO/LPS34164.

OMG Center for Collaborative Learning (2008), *Digital Inclusion Program: Final Report of the Rapid Assessment* (final revision), December 1, available at http://wirelessphiladelphia.org/documents/12-1%20WP%20Rapid%20Assessment%20Report%20Final.pdf.

OMG Center for Collaborative Learning (2009), *Learning More about What Works: Short-Term Client Outcomes of the Sustainable Broadband Adoption Pilot Program*, July 28, available at http://www.wirelessphiladelphia.net/documents/DIG%20Interim%20Report%207-28-09%20final.pdf.

Ono, Hiroshi (2006), "Digital Inequality in East Asia: Evidence from Japan, South Korea, and Singapore," *Asian Economic Papers* 4(3):116-139.

Pollio, David E. and Karen A. Truscott (2004), *Grace Hill M.O.R.E. for Head Start: TOP Initiative Evaluation Report*, unpublished report.

Prieger, James E. and Daniel Heil (forthcoming), "The Microeconomic Impact of E-Business," in I. Lee (Ed.), *Encyclopedia of E-Business Development and Management in the Global Economy*, Hershey, PA: IGI Global.

Prieger, James E. and Wei-Min Hu (2008), "The Broadband Digital Divide and the Nexus of Race, Competition, and Quality," *Information economics and Policy* 20:150-167.

Puma, Michael J., Duncan D. Chaplin, Kristin M. Olson, and Amy C. Pandjiris (2002), "The Integrated Studies of Educational Technology: A Formative Evaluation of the E-rate Program (Draft)," Urban Institute, Washington, DC, available at http://www.urban.org/url.cfm?ID=410579.

Rappoport, Paul, Donald Kridel, and Lester Taylor (2002), "The Demand for Broadband: Access, Content, and the Value of Time," in Robert W. Crandall and James H. Alleman (Eds.), *Broadband: Should We Regulate High-Speed Internet Access?* Washington, DC: The Brookings Institution.

Rappoport, Paul, Donald Kridel, Lester Taylor, and James Alleman (2001), "Residential Demand for Access to the Internet," In Gary Madden (Ed.), *Emerging Telecommunications Networks: The International Handbook of Telecommunications Economics, Volume II*, Edward Elgar Publishers, Cheltenham, UK, pp.1-20.

Rosston, Gregory, Scott Savage, and Donald Waldman (2010) "Household Demand for Broadband Internet in 2010," forthcoming in *Advances in Economic Analysis & Policy*,

Savage, Scott J. and Donald M. Waldman (2004), "United States Demand for Internet Access," *Review of Network Economics* 3(3):228-247.

Savage, Scott J. and Donald M. Waldman (2009), "Ability, Location and Household Demand for Internet Bandwidth," *International Journal of Industrial Organization* 27: 166–174.

Stoneman, Paul L. and Paul A. David (1986), "Adoption Subsidies vs Information Provision as Instruments of Technology Policy," *Economic Journal* 96: 142-150.

Stoneman, Paul L., and Paul Diederen (1994), "Technology Diffusion and Public Policy," *Economic Journal* 104(425): 918-930.

Strover, Sharon (2009), "America's Forgotten Challenge: Rural Access," ch. 11 in *...and Communications for All: A Policy Agenda for the New Administration*, A.M. Schejter (Ed.), Lanham: Lexington Books.

Tsikalas, Kallen, Jihyun Lee, and Christine Newkirk (2007), "Home Computing, School Engagement and Academic Achievement of Low-Income Adolescents: Findings from Year One of the Three Year Study of the CFY Intervention," unpublished manuscript from Computers for Youth and the Educational Testing Service, available at http://www.theddi.org/forms/CFY-ETS%20 Study.pdf.

Turk, Tomaž, Borka Jerman Blažič, and Peter Trkman (2008), "Factors and Sustainable Strategies Fostering the Adoption of Broadband Communications in an Enlarged European Union," *Technological Forecasting & Social Change* 75:933–951.

Varian, Hal R. (2002), "The Demand for Bandwidth: Evidence from the INDEX Project," in Robert W. Crandall and James H. Alleman, *Broadband: Should We Regulate High-Speed Internet Access?* Washington, DC: The Brookings Institution.

Wallsten, S. (2006), "Broadband and Unbundling Regulations in OECD Countries," Working Paper 06-16. Washington, D.C.: AEI-Brookings Joint Center for Regulatory Studies.

Ward, Michael R. (2005), "Rationalizing the E-Rate: The Effects of Subsidizing IT in Education," *NET Institute Working Paper* No. 05-25, available at http://ssrn.com/abstract=851447.

Wilson, Kenneth (2008), "North Carolinians Online: Tracking Home Computers and Internet Access in North Carolina 1999 to 2008," November, available at http://www.e-nc.org/pdf/2008_Citizen_Survey.pdf.

Youtie, Jan, Philip Shapira, and Greg Laudeman (2007), "Supply, Demand and ICT-Based Services: A Local Level Perspective," *Telecommunications Policy* 31:347–358.