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Broadband Penetration: An Empirical Analysis of State and Federal Policies

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Executive Summary

High-speed, or broadband, access to the Internet is becoming ubiquitous, but some policymakers are concerned that broadband penetration in the United States is increasing too slowly, especially compared to other countries. As a result, cities, states, and the federal government are adopting policies intended to quicken broadband growth. These policies include attempts to streamline rights-of-way laws, telecommunications unbundling regulations, subsidies, and direct municipal broadband provision. To date, however, little empirical research has explored whether these policies, especially at the state level, are effective.

In this paper I combine data from several publicly-available sources to test the effects of a number of policies. The analysis reveals that most state-level policies are ineffective. Universal service mechanisms and programs targeted at "underserved" areas do not boost broadband penetration and may even slow it, possibly by giving an artificial advantage to one type of provider over another. Likewise, tax incentives appear to have no impact. Laws limiting municipal deployment of broadband are not statistically significantly correlated with broadband penetration. Other policies, however, do appear to affect broadband penetration. Access to public rights-of-way by broadband providers is strongly correlated with penetration. Telecom unbundling regulations also affect penetration: the share of telephone lines provided under UNE-P regulations is negatively correlated with penetration, but resold lines are positively correlated with it. Some programs targeting rural access may have some positive impact. Subsidies from USDA's Rural Development broadband program are not correlated with increased rural access to broadband, but subsidies from USDA's broader telecommunications program are, though the analysis suggests that it is probably not a cost effective way to increase broadband access.

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1. Introduction

High-speed access to the Internet, or broadband, is becoming ubiquitous. At the same time, some policymakers and others are concerned that the United States is not adopting broadband fast enough (e.g., Ferguson 2002;Hundt 2002). In 2004, the U.S. ranked tenth in the world in terms of broadband adoption per capita, and many agreed with President Bush when he noted that "Tenth is 10 spots too low."[1] According to the International Telecommunications Union, by the beginning of 2005 the U.S. had fallen to 16th in broadband penetration.[2] Others argue that such rankings are not meaningful and that Americans are adopting broadband at least as swiftly as previous new technologies (Crandall 2004a;Faulhaber 2002). Regardless of whether broadband is, in fact, growing "too slowly," universal broadband adoption could yield significant economic benefits (Crandall and Jackson 2001;Crandall, et al. 2002;Litan and Rivlin 2001). As a result, there has been a great deal of interest in policies that might encourage faster adoption of broadband Internet connections.

Policies intended to accelerate broadband adoption have included telephone line-sharing and unbundling regulations, subsidies for private providers and consumers, direct government provision of broadband services, and attempts to streamline access to public rights-of-way, to name a few. Many of these policies, described in more detail below, are undertaken at the state or city level. Indeed, every state regulates telecommunications, and these regulations can greatly affect the industry (Kim and Buckley 2004). Unfortunately, it is difficult to collect comprehensive data on state-level policies. As a result, little empirical research focuses on the effectiveness of state-level broadband policies.

In this paper I evaluate state-level data to assess the impacts of policies at the sub-national level on broadband adoption. In particular, I combine data from the Federal Communications Commission (FCC), information on state-level policies recently compiled by

[1] http://www.whitehouse.gov/news/releases/2004/04/20040426-6.html
[2] Behind Hong Kong, South Korea, The Netherlands, Denmark, Canada, Switzerland, Taiwan, Belgium, Iceland, Sweden, Norway, Israel, Japan, Finland, and Singapore.

the California Public Utilities Commision (PUC) (2005), and data from a variety of other publicly-available sources to test the effects of rights-of-way regulations, subsidies, direct government support for broadband rollout, and unbundling regulations. These data limit the rigor of the analysis. For example, I do not have information on the size of various state policies or when they began. In addition, while the state-level data shows broadband subscriptions per capita, the rural data shows only the share of a state's rural population that lives in zip codes with at least one provider. Nonetheless, the analysis provides a first empirical look at policies that are becoming increasingly popular.

Controlling for population, income, urbanization, venture capital, the governor's political party, and year fixed-effects, I find that guaranteed access to rights-of-way is strongly correlated with improvements in broadband penetration while universal service mechanisms and programs targeted at "underserved" areas do not appear to improve penetration and may even be detrimental to it. The share of telephone lines provided as UNE lines is correlated with slower growth in ADSL service, while the share of lines provided through resale programs is correlated with faster growth in ADSL and total broadband penetration. State laws restricting the ability of municipalities to build broadband networks are not significantly correlated with penetration.

Some programs intended to improve rural access may have a positive impact. State grants supposedly targeted at rural areas are positively correlated with increased total broadband penetration, though not consistently significant across specifications. On the federal level, the USDA Rural Development broadband program is not correlated with changes in rural access to broadband. USDA's broader telecommunications program, however, is correlated with increased rural broadband access, but the analysis suggests that it spends about $1500 per person who gains access (but does not necessarily subscribe).

2. Broadband Growth and the Desire for More

High-speed connections to the Internet started to become commonplace in the late 1990s. One of the first technologies widely available to residential and small business consumers was Integrated Services Digital Network (ISDN), which allowed existing telephone lines to transmit data faster than could traditional dialup modems. Just like today's concerns that government should do more to speed broadband rollout, then there were calls for faster ISDN rollout. The

Texas PUC, for example, required Southwestern Bell Telephone Company to make ISDN available to all Texas consumers (Common Carrier Bureau 1998). In 1997, one consumer group called for ISDN price controls because “the best available here-and-now residential technology is ISDN” and “if new technologies like cable modems or ADSL are truly seven years from widespread deployment, we must do something about the present” (Love 1997).

As it turned out, ISDN was a fairly short-lived technology that was expensive and relatively slow, supporting speeds only up to 128 Kbps, or about three times as fast as a dialup modem. ADSL and cable modems were just around the corner and could provide faster speeds at lower costs than could ISDN. As Figure 1 shows, broadband penetration in the United States accelerated dramatically as ADSL and cable modems became available. Today, ADSL and cable are the primary means of delivering broadband Internet services, but other modes are developing rapidly, including wireless via WiFi and WiMax, satellite, and over power lines.

Despite this fast growth and emerging new technologies, some policymakers and others worry that broadband adoption in the United States is lagging.[3] This concern, plus the benefits that might accrue from increased access to broadband, have caused federal, state, and local policymakers to search for ways to increase penetration. State and local policies include attempts at streamlining rights-of-way regulations, direct subsidies for broadband providers or consumers, and government ownership of broadband infrastructure. Some other policies originate at the federal level but differ across states. Telecommunications unbundling regulations, for example, were initially mandated by the FCC as part of the 1996 Telecommunications Act, but prices for the unbundled elements of the telecommunications infrastructure were generally set by state regulators. In addition, the U.S. Department of Agriculture (USDA) Rural Development program provides local grants for a variety of development initiatives, including about $1 billion per year for investments in telecommunications infrastructure.

Despite the large number of broadband initiatives and the continued call for new ones, there is little empirical analysis of their effectiveness. Aron and Burnstein (2003) find that competition between providers is an effective catalyst for increased penetration, and argue that

[3] Not only is the percentage of U.S. residents with broadband connections lower than in many other counties, as discussed above, but in some other countries it is possible to subscribe to services several times faster than those available in the U.S. In Japan, for example, it is possible to obtain connections as fast as 100 Mbps, compared to services in the U.S. that typically offer download speeds from 1 Mbps or less to 8 Mbps. I do not address the issue of speed in this paper.

policies should thus focus on removing obstacles to competition. Goolsbee (2002) argues that if policymakers want to employ subsidies to increase broadband penetration, then subsidies targeted at encouraging investment in unserved areas will be more effective than subsidies targeted at individual consumers. Flamm (2005) finds that geographic terrain, income, and population density are important determinants of broadband penetration, while the eRate program, intended to help connect schools and libraries to the internet, has little impact on broadband penetration His empirical results find significant state fixed effects, suggesting that state-level policies might matter, though he does not test them. Faulhaber (2002) notes that state and local policies can also impede broadband rollout by, for example, imposing costly requirements on infrastructure providers. Crandall, et al. (2004) agree that state policies can affect broadband investment and should be sure not to inhibit competition.

In this paper I combine data from a number of publicly-available sources to test the effects of a variety of policies on broadband adoption. Below I discuss the data and data sources, specific policies and what research has found to date, the framework for analyzing the data, and the results.

3. Broadband Policies

One of the challenges in analyzing sub-national policies is that data are rarely collected at this level in a systematic fashion. Fortunately, several recent reports have done just that, making it possible to combine information on state policies with detailed FCC and Census data to test the effects of those policies on broadband adoption. In particular, in May 2005 the California Public Utilities Commission (PUC) released a report on broadband in California, and in an appendix notes which states have adopted particular policies (California Public Utilities Commission 2005).[4] The Department of Commerce provides information on rights-of-way regulations.[5] The USDA Rural Development agency provides state-level data on subsidies for rural broadband and telecommunications. The FCC has data on telecommunications unbundling and broadband penetration.

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[4] Analysys Consulting (2003) prepared similar tables, but unlike the California PUC report, their tables do not include all 50 states plus the District of Columbia.

[5] See http://www.ntia.doc.gov/ntiahome/staterow/rowtableexcel.htm. The NTIA notes that they assembled the data "with reliance on existing research by NARUC and NATOA."

Rights of Way

Extending or improving broadband service often involves adding fiber optic cables, upgrading 'last mile' connections, or finding places to locate antennae for wireless services. Building this infrastructure usually requires access to public (and private) rights-of-way. The California PUC and the National Association of Regulatory Utility Commissioners have identified access to rights-of-way as one of the most vexing problems facing broadband rollout (California Public Utilities Commission 2005;Study Committee on Public Rights-of-Way 2002).

The desire of states and cities to regulate access to rights-of-way is understandable. The costs of digging up streets, for example, exceed the simple costs of digging, laying cable, and filling holes. The process can also disrupt traffic and inconvenience local residents—externalities that may not be internalized absent regulation. The California PUC notes, however, that "[t]he process for obtaining Right of Way permits for construction of broadband infrastructure in California is lengthy, expensive, inconsistent and is cited as one of the most significant barriers to broadband deployment. Rights-of-way permits are issued by various agencies—federal, state and local agencies, as well as tribal governments—to build broadband infrastructure on property controlled by those agencies. There is no consistency in the application form or process, or in the permitting criteria or fees" (California Public Utilities Commission 2005). While some regulations regarding access to rights-of-way are necessary, arbitrary complexities and differences across jurisdictions can increase the costs of improving existing broadband connections or adding new service.

The complexity of rights-of-way regulations also makes it difficult to create a variable that quantifies access to rights-of-way. Many states, however, have laws guaranteeing telecommunications companies access to rights-of-way. While telecommunications firms obviously gain access to public rights-of-way in states without such laws and telecom firms in states with these laws still must deal with municipalities regarding fees and other details, I believe it is reasonable to assume that this variable indicates states in which it is relatively easier for telecommunications firms to use public rights-of-way. Twenty-one states make such guarantees to telecom firms.[6]

[6] I created a dummy variable indicating whether the state provides such guarantees as indicated by the Department of Commerce table available at http://www.ntia.doc.gov/ntiahome/staterow/rowtableexcel.htm (last accessed May 17, 2005). However, it is not always possible to determine definitively from the table whether telecom firms are given these guarantees; a few cases were ambiguous. To test the robustness of the analysis below, I coded these

Cable TV companies also require access to rights-of-way in order to build their infrastructure. Several of the states that guarantee telecom firms access to public rights-of-way exempt cable companies from state-level rights-of-way regulations. Whether such exemption is good or bad for cable companies is unclear. Firms often benefit from being exempt from regulation. Indeed, some argue that broadband via coaxial cable grew more quickly than via ADSL because telecommunications companies were subject to federal regulations while cable companies were not (e.g., Crandall, Hahn, Litan, and Wallsten 2004). Cable companies, however, are regulated at the local level, and being exempt from state regulations regarding rights-of-way may mean that cable companies cannot benefit from the laws that guarantee telecom firms rights-of-way access. Six states explicitly exempt cable companies from these regulations.

State-level Broadband Policies

States and cities are engaged in a number of efforts to stimulate broadband adoption. The California PUC (2005) report notes which states have adopted particular policies. Table 1 reproduces this information to show the number of states that have adopted each of the policies catalogued in the report. The table shows that some policies are ubiquitous and others are less common. Every state, for example, makes some state services available online hoping to increase both accessibility to those services and demand for broadband. While online services probably reduce transactions costs for citizens when dealing with state or local governments, it seems unlikely that online services would increase broadband demand. Broadband makes it easier to transmit large amounts of data in less time—an activity in which most people probably do not often engage when dealing with state government services. At the other extreme, only two states attempt to regulate broadband quality. Unfortunately, the lack of variation across states in the use of these two policies means that this empirical analysis cannot evaluate their effectiveness.

Adoption of other policies varies much more across states. Some states provide subsidies—grants or loans—to providers to expand service to rural or “underserved” areas while some provide subsidies directly to consumers. These subsidies are often in the form of tax

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states as 0.5, rather than 0 or 1, and re-ran the analyses. The results were robust to the change.

credits to private providers, and sometimes direct payments to firms or non-profits, for building in certain areas.

Cities sometimes build their own broadband infrastructure, which can range from fiber optic loops to citywide WiFi networks. These practices, especially the latter, have been controversial. Proponents claim that such public investments can be a cost-effective way to bring broadband to a large number of people. Opponents claim that these projects primarily benefit the relatively wealthy who are likely to have broadband access already and discourage investment by broadband providers. Some states have responded to initiatives like these by passing laws making it difficult for cities to invest in broadband infrastructure or prohibiting the practice completely.[7]

USDA Rural Development Grants

The USDA Rural Development agency provides loans and grants intended to "increase economic opportunity and improve the quality of life in rural America" (Rural Development 2005). In 2004 the agency made more than $14 billion available to rural areas for various development projects. While USDA Rural Development's largest programs involve electricity, nearly $1.4 billion were loans for telecommunications projects in 2004 (up from $700 million in 2000). The telecommunications program provides funds for "initial construction, improvement, or expansion of telecommunications infrastructure; loans and grants for distance learning and telemedicine initiatives; and loans and grants for the deployment of broadband services." Projects specifically targeted at broadband have increased from $100 million in 2001 (the first year broadband-specific loans were available) to $600 million by 2004.

According to the USDA Rural Development agency (2005), "[s]ince 2001, Rural Development has utilized a variety of loan and loan guarantee programs to provide over $3 billion in funding and assist over 1.3 million rural subscribers in accessing new broadband technologies." The USDA's claim notwithstanding, I am not aware of empirical research investigating the effectiveness of Rural Development's telecommunications or broadband subsidy program.

[7] In the CPUC report, the variable "Does the state limit municipal deployment of broadband services?" generally indicates whether or not there are laws prohibiting municipal entities from providing basic local exchange services or whether the state imposes burdensome requirements on municipal providers of communications services.

Unbundling

The 1996 Telecommunications Act required incumbent telecommunications firms to lease their facilities to competitors under the theory that incumbents controlled monopoly "bottlenecks." While these unbundling rules were intended primarily to promote competition in traditional telecommunications, advocates also believed that they would be important in broadband adoption (Frieden 2004). Research to date, however, shows little impact of unbundling on broadband internationally (e.g., Bauer, et al. 2003;Garcia-Murillo and Gabel 2003;Hausman and Sidak 2004).[8] Crandall (2004b) notes that broadband penetration in Canada is about 60 percent higher than in the U.S., and that Canada has less onerous unbundling requirements for local telephone companies and virtually no network sharing for competitive broadband suppliers.

Until 2004, the FCC allowed competitors to purchase all the elements necessary to provide service at regulated rates. By re-assembling the entire platform under regulated rates (called Unbundled Network Element-Platform, or UNE-P), competitors could offer voice services with little investment in their own facilities. Line sharing regulations allowed competitors to provide ADSL service over the incumbent's copper lines. In its August 2003 decision the FCC began moving away from these regulations, loosening some "unbundling" requirements, eliminating the right of entrants to share the incumbents' lines at these low prices.[9] And while the FCC wanted to permit states to continue to allow UNE-P, the DC Circuit Court reversed that decision, effectively ending the UNE-P regime.

The FCC provides data on the number of telephone lines by state. In particular, the agency's annual reports on local telephone competition detail the number of lines by state each year, including the share of lines provided by competitive local exchange carriers (CLECs) through UNE-P and resale of the incumbent local exchange carrier (ILEC) facilities.[10] Because UNE-P regulations were targeted at voice competition they did not directly affect broadband

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[8] The role of UNE regulations on development of traditional telecommunications has been similarly controversial. Some believe they were crucial in promoting competition (e.g., Clarke, et al. 2004), while others believe they reduced investment incentives and were a total failure (e.g., Hazlett 2005).

[9] Federal Communications Commission (2003). By this order, the FCC describes: "We eliminate most unbundling requirements for broadband, making it easier for companies to invest in new equipment and deploy the high-speed services that consumers desire. We have also made new decisions concerning the unbundling of other network elements that result in substantial changes to existing requirements, including a more granular analysis of unbundling requirements by the states when appropriate."

[10] http://www.fcc.gov/wcb/iatd/comp.html

provision. Those regulations, did, however, affect the incumbent's investment incentives. Critics argue that these regulations reduce the returns to ILEC investments, therefore reducing their incentive to invest (e.g., Crandall 2005;Hazlett 2005;Hazlett, et al. 2004). Supporters argue that the gains from competition resulting from UNE-P more than offset those disincentives (e.g., Clarke, Hassett, Ivanova, and Kotlikoff 2004;Ford and Spiwak 2004).

UNE-P and resale are similar in that they both allow CLECs to sell local exchange service under their own brand names, but pricing methods are different. UNE regulated prices were supposed to reflect the cost an ILEC would incur to provide each network element, while resale prices were supposed to be a discount from retail prices reflecting the ILEC's avoided costs of providing certain customer services. It was generally less expensive for CLECs to provide service through UNE lines, as evidenced by the fast growth of UNE lines as a share of all CLEC lines over time (Figure 2).

4. Broadband Data and Analysis

Most of the data on broadband penetration come from the FCC's annual reports, "High-Speed Services for Internet Access."[11] I use three measures of broadband penetration by state from this source to test the effects of various policies: the total number of broadband connections, the number of ADSL connections, and the number of connections over coaxial cable.

Because some policies are explicitly aimed at increasing rural broadband access, I construct a separate variable intended to capture broadband access in rural areas. Each year the FCC reports the number of high-speed service providers in each zip code. The U.S. Census, meanwhile, reports the rural and urban population of each zip code. Together, these two sources make it possible to calculate the share of each state's rural population that lives in zip codes with a given number of high-speed providers.

These data on rural penetration have certain limitations. First, while the broadband penetration figures above are based on estimates of the number of broadband subscribers, it is important to emphasize that this rural data is based on the number of people who live in zip codes with a given number of broadband providers. While we can be reasonably certain that

[11] http://www.fcc.gov/wcb/iatd/comp.html

nobody in zip codes with zero providers has broadband (except possibly via satellite), for zip codes with at least one provider we have no way of what share of the population has access and what share of those with access actually subscribe. Second, for confidentiality reasons, the FCC often reports that "one to three" firms, rather than a specific number, provide broadband service in a zip code. I focus on whether policies affect the share of the rural population with access to at least one broadband provider. Third, the zip code population figures and rural-urban breakdown come from the 2000 Census, so they do not change over time. Only the number of broadband providers in each zip code changes over time. The constant population is unlikely to cause problems in the analysis as the share of a state's population that is rural should not change dramatically from year to year.

Analysis: Policies and Broadband Penetration

To evaluate the effects of broadband policies, I regress the various measures of broadband penetration on the policy and control variables. In particular, I estimate several versions of equation (1):

$$(1) \qquad y_{it} = \beta_0 + \beta_1(\text{policy variables}_i) + \beta_2(CLEC_{it}) + \delta(Z_{it}) + \gamma_t + \varepsilon_{it}$$

Where y_{it} is the number of broadband subscribers per capita in state *i* in year *t*. The policy variables are dummies indicating whether the state specifically grants telecom firms access to public rights-of-way; whether cable companies are excluded from these state-level rights-of-way regulations; whether the state limits municipal deployment of broadband infrastructure, uses universal service mechanisms to stimulate broadband, offers grants or loans to private providers to offer broadband in "underserved" areas, offers grants or loans to private providers to offer broadband in rural areas, and offers tax incentives to broadband providers. Note that because the data sources do not indicate when states adopted these policies, the policy variables do not vary over time. For purposes of analysis, I assume that these policies were in effect from the year 2000 in all states. $CLEC_{it}$ is a vector of two variables: the share of telephone lines in a state-year provided by CLECs as UNE-P lines, and the share of telephone lines in a state-year that are provided by CLECs under resale programs.

$\boldsymbol{Z_{it}}$ is a vector of control variables intended to capture aspects of demand for broadband and costs of supplying broadband. Demand variables include median household income, urbanization, population, and private venture capital.[12] As a proxy for the cost of provision I include the share of the population that lives in urban areas because it is presumably less expensive to provide broadband in areas where people are more densely concentrated. I include the party of the state's governor to control for political factors that may influence rollout. Finally, year fixed effects control for the time trend—crucial for a new technology that is being rapidly adopted across the country regardless of policies.

Because policies may be correlated—that is, a state may be more likely to enact one policy when it has another—I first estimate the equation including all the policy variables, and then estimate it for each variable separately as a robustness check. In addition, I estimate the effects of each policy variable separately on three measures of broadband access: total broadband lines per capita, ADSL lines per capita, and coaxial cable lines per capita.

Tables 2 and 3 show the results of estimating this series of equations using ordinary least squares. Table 2 shows the results of estimating the equation with all policy variables included simultaneously, while Table 3 shows the results of separate regressions for each policy variable as a robustness check. Access to public rights-of-way, consistent with the discussion above, is statistically significantly correlated with broadband penetration. Interpreted causally, the coefficient suggests that mandated access to rights-of-way can increase broadband penetration by 0.006 lines per capita, or about ten percent when evaluated at the mean in the dataset. Likewise, denying cable companies those same rights is correlated with lower broadband penetration. The coefficients suggest that excluding cable companies from these regulations is correlated with 0.009 fewer total lines per capita or 0.01 fewer cable broadband lines per capita. The effect on cable lines appears quite large since the mean per capita number of cable broadband lines is only 0.04.[13] This result on cable lines, however, is not robust. When the equation includes only the rights-of-way variables and not the other policy variables, the effect of cable rights-of-way becomes statistically insignificant and the magnitude of the coefficient is much smaller.

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[12] Income, urbanization, and population come from the U.S. Census. The venture capital data comes from the PricewaterhouseCoopers MoneyTree survey (http://www.pwcmoneytree.com/moneytree/index.jsp). I also tried including other demand shifters in the analysis, including education, the share of people with no telephone, poverty indicators, and shares of a state's population in different industrial sectors. These variables, however, are correlated with each other and the variables discussed above included in the regression. I ultimately excluded these because the included variables seemed more likely to capture underlying demand conditions, and including these did not affect the main results but made it difficult to interpret the coefficients on the control variables.

[13] Note that this broadband penetration figure seems low because it is an average of all years from 2000, when penetration was fairly low, to 2004.

The results on other state policies are mixed. Using "universal service mechanisms" does not appear to increase broadband penetration. In fact, the analysis shows a statistically significant negative correlation between using universal service mechanisms and broadband penetration, with the negative effect coming from the large negative impact on cable broadband penetration. This result is sensible: universal service programs typically benefit (and directly cost) only telecommunications firms. A program that uses universal service funds to promote broadband may subsidize ADSL at the expense of cable. In other words, these programs are likely to treat different delivery methods (ADSL and cable) of the same good (broadband connection) differently, distorting investment and competition. The negative result on universal service programs is consistent with Aron and Burnstein's (2003) argument that policies that favor one type of investment over another can be self-defeating and "frustrate policy objectives to increase adoption."

Private sector grants and loans to "underserved" areas appear to be either ineffectual or detrimental to broadband rollout. Tax incentives have either no impact or a slightly negative impact on broadband rollout, though the negative result is not robust. While loans targeted at rural areas do not appear to be effective, grants targeted at rural areas are statistically significant and correlated with increases in broadband penetration. I will explore the rural issue in more depth below.

State laws limiting cities' ability to provide broadband appear to have little impact. The coefficient is negative, but not statistically significant. Recall that proponents of these laws argue that broadband providers are more likely to invest if they know that the government will not expropriate or undercut their services by, for example, subsidizing the cost of broadband provision through taxes. The concern is legitimate. Reducing the returns to providers' investments also reduces their incentive to innovate. Contrarily, though, it is also possible that some government investments would be complements to private networks or that government-owned networks act as competition, spurring additional private investment. Unfortunately, the results here provide comfort to neither side: the presence of laws restricting municipal provision of broadband services is not statistically significantly correlated with broadband penetration.

Unbundling regulations also appear to matter for broadband rollout. The share of UNE lines is statistically significantly negatively correlated with ADSL rollout. In other words, the larger the share of telephone lines in a state provided under the UNE regulations, the slower the rollout of ADSL. This result is consistent with the claims of UNE-P critics that those regulations reduced ILEC investment. Contrarily, the share of lines provided by CLECs under total service resale (TSR) is statistically significantly positively correlated with total broadband penetration, ADSL penetration, and (weakly) cable penetration.

It is difficult to interpret the positive result on the share of lines provided through TSR. It may indicate that resale competition from CLECs stimulated ILEC investment. The result, however, may also simply be reinforcing the negative UNE result. That is, the share of TSR lines will be higher in states in with relatively higher ratios of regulated UNE prices to TSR prices. If UNE discourages investment and high TSR proxies for low UNE, then a positive result on TSR could imply an additional negative impact of UNE lines not captured in the UNE variable.[14]

Among the control variables, household income and urbanization are generally positively correlated with broadband penetration, as one would expect. Venture capital was, surprisingly, not statistically significant. Having a Republican governor was negatively and statistically significantly correlated with broadband penetration.

Rural penetration

The analysis above suggested that some policies aimed at increasing rural broadband penetration may have been successful. I investigate that result more carefully here by explicitly testing the effects of policies on rural, as opposed to total, penetration. I re-estimate equation (1) with two changes. First, I include two new policy variables: the amount of money provided to each state each year under USDA's Rural Development broadband program and the amount provided under USDA's broader telecommunications program.[15] Second, the dependent variable becomes the number of rural dwellers in zip codes with at least one broadband provider, as discussed above. More specifically, because the main policy variable of interest is the flow of USDA Rural Development dollars, I use changes in the rural population with broadband access as the dependent variable. That is, it seems more appropriate to examine the effects of a flow of dollars on changes in the number with access, rather than the total number of people with access,

[14] I thank Tom Hazlett for pointing this out to me.

[15] More specifically, one variable is state-year broadband funding, and the second variable is state-year telecommunications funding less the amount designated specifically for broadband.

since a sudden stop in the flow of subsidies could affect the number of people who gain access, but not the number that already have it.

Table 4 shows the results of estimating this equation. None of the state policies, including those specifically targeted at rural areas, is correlated with improvements in this measure of rural service. The USDA's broadband program is also not statistically correlated with improvements in rural broadband access. USDA's broader telecom program, however, is robustly statistically significantly correlated with improvements in rural access. Regardless of which variables are included or excluded, these telecom subsidies are positively correlated with increases in the rural population with access to at least one broadband provider.

The results suggest that the Rural Development telecommunications program, if not the broadband component of it, is promoting rural broadband adoption, but additional analysis is required to assess whether it is a cost-effective way of increasing access. The coefficient estimates suggest that for each $1000 invested by the telecommunications program, an additional 0.6 – 0.7 people gain access. That is, the program spends on average about $1428 - $1667 per additional person who gains access to at least one broadband provider.

This estimate, however, is problematic. Several factors may bias the estimate towards making the program appear either less or more cost-effective than it is in reality. Consider the ways the analysis might make the program appear less cost-effective. First, the estimate is based on expenditures by the Rural Development program's telecommunications program excluding amounts specifically aimed at broadband. While access to telecommunications services can be a prerequisite for broadband access, broadband access was not a primary focus of the program until recently. It is possible, therefore, that any increased broadband access from this part of the telecommunications program is just a happy byproduct of the program's true intent.

Second, while people living in zip codes with no broadband providers almost surely have no broadband access, the share of the population living in such zip codes understates the number of people who do not have broadband and probably underestimates the number of people who could not access broadband even if they wanted to. In other words, the estimate may overstate the subsidies targeted at broadband and undercount the number of potential beneficiaries.

Other factors, however, bias the estimate in the other direction, making it appear more cost-effective than it actually is. First, the analysis explores the effects of the program on the number of people living in zip codes with at least one broadband provider. When a broadband provider begins operating in a zip code, it will not necessarily be accessible by the entire population and not everyone with access will subscribe, meaning that the dollars spent per person who then becomes a broadband consumer is probably higher than this estimate suggests. Second, while the USDA's program funds telecommunications, the first broadband provider in a zip code might be one, like cable, that does not receive subsidies from the USDA program. In that case, this analysis would mistakenly attribute the increase in access to the USDA program. In other words, the estimate may overstate the number of people who gain access to broadband and the number of providers supported by this program.

While the analysis in this paper does not find a significant correlation between USDA broadband spending and broadband access, USDA Rural Development (2005) claims that "Since 2001, Rural Development has utilized a variety of loan and loan guarantee programs to provide over $3 billion in funding and assist over 1.3 million rural subscribers in accessing broadband." The report does not provide any details on how the number 1.3 million was determined, or whether any empirical testing was done to determine whether the program itself was responsible for making broadband available to those 1.3 million people.

However, taking USDA's numbers at face value implies that USDA Rural Development spent about $2,300 per person connected. USDA's numbers thus seem to suggest that the program is not cost effective. For the same cost, for example, USDA could have paid for all 1.3 million people to subscribe to satellite broadband services for nearly five years.[16]

5. Discussion and Conclusion

As the debate over U.S. broadband adoption rages, cities, states, and the federal government continue to adopt policies aimed at increasing broadband penetration. To date, however, there has been little analysis of the effectiveness of such programs, especially at the sub-national level. In this paper I combine broadband and telecommunications data from the FCC with information on state-level policies compiled by the California Public Utilities Commission, information on rights-of-way from the U.S. Department of Commerce, data on

[16] Starband Residential, for example currently offers a package that includes equipment and two years of service for $599, and then $49.95 per month for the third year. http://www.starband.com/residential/pricing.asp (last accessed June 24, 2005).

rural telecommunications grants from the USDA Rural Development Program, and the US Census to test the effects of various policies on broadband penetration.

The analysis reveals that most state-level policies are *ineffective*. Universal service mechanisms and programs targeted at "underserved" areas do not boost broadband penetration and may even slow it, possibly by giving an artificial advantage to one type of provider over another. Likewise, tax incentives appear to have no impact. Laws limiting municipal deployment of broadband are not statistically significantly correlated with broadband penetration.

Unbundling regulations, meanwhile, have a mixed effect on broadband penetration. UNE lines are negatively correlated with broadband penetration, consistent with claims that UNE regulations deterred investment. Resale of telephone lines by CLECs, however, was correlated with increases in broadband penetration, perhaps suggesting that CLECs did provide some competition, but not through UNE lines.

Some policies appear to have a positive impact on broadband penetration. Access to rights-of-way matters a great deal: guaranteed access to public rights-of-way is strongly correlated with increases in broadband penetration. These results support calls by the California PUC and the National Association of Regulatory Utility Commissioners to simplify and standardize regulations regarding rights-of-way. Likewise, some programs targeted at rural areas may have a positive effect. Expenditures by USDA's Rural Development broadband program are not correlated with increases in broadband access, but expenditures from USDA's broader telecommunications program are, though it does not appear to be cost-effective. While I find no significant correlation between broadband subsidies and rural access, USDA's own numbers imply that the broadband program has spent nearly $2300 per person connected. An analysis here of the broader telecommunications program suggests that it spends about $1500 for each person who gains access to—but does not necessarily purchase—broadband service.

The analysis in this paper is not without problems, however. First, I do not currently know when the state programs took effect and simply assume that these programs were in effect from the year 2000 onwards. Knowing the year each state began its programs would provide for more rigorous testing of their effectiveness and allow the analysis to control for state fixed effects. Second, the state policy variables are dummy variables indicating only whether or not a state has a particular type of policy. These dummy variables mask differences in each state's approach and contain no information as to the size—relative or absolute—of each program. Third, as discussed above, the rural data are problematic in that they show only the number of people who live in rural parts of zip codes with no broadband providers. The true number of people in rural areas without access may be different.

Endogeneity may also be a problem. For example, the negative coefficient on using universal service mechanisms to increase broadband could mean either that the program slows broadband penetration or, contrarily, that perhaps states with slower broadband adoption are the ones that use these tools to address the issue. However, I believe that in this case reverse causality is unlikely for two reasons. First, I control for many of the factors that explain low penetration, like income and urbanization. Second, because universal service mechanisms are generally used for telecommunications but not cable companies, one would expect to see some correlation with ADSL penetration if reverse causality were a problem. Instead, the negative correlation is primarily with cable modem, not ADSL, penetration. It seems less likely that policymakers would turn to a tool targeted at telecommunications companies in response to slow growth in cable modems.

Despite its weaknesses, however, this paper provides empirical evidence on the effectiveness of a number of policies aimed at increasing broadband. Some policies matter a lot. Access to rights-of-way is, not surprisingly, important in boosting broadband access. Most state initiatives do not have the desired effect and some—those that use the universal service program and those that target “underserved” areas—may even be counterproductive. State laws blocking municipal broadband have little impact, positive or negative, on broadband penetration. Some programs targeted at rural areas appear to boost broadband penetration, but the analysis suggests that they may not be cost-effective. Telecommunications unbundling regulations have an impact, as well: UNE regulations appear to hinder investment in broadband while non-UNE resale seemed to boost broadband penetration, perhaps through competition provided by CLECs.

Overall, the analysis reveals that not all policies intended to boost broadband penetration actually do. Some policies intended to make a state more broadband-friendly could have the unintended consequence of deterring investment by broadband providers. On the other hand, some policies do appear to induce additional investment and boost penetration. Further research should explore these in more depth to better determine under what conditions certain policies are effective and when they are cost-effective.

Table 1

Number of States Adopting Broadband Policies

Policy	**Number of states**
Has an E-government initiative	51
Designated lead agency for broadband deployment	39
Offers private-sector grants targeted to deployment in underserved areas	22
Maintains databases or maps of existing broadband facilities	17
Offers private-sector grants targeted to deployment in rural areas	17
Offers tax incentives to broadband providers	15
Limits municipal deployment of broadband services	14
Has expedited rights-of-way policies	13
Offers private-sector loans targeted to deployment in underserved areas	12
Uses universal service mechanisms to attract broadband deployment	8
Offers loans to broadband providers	7
Offers grants to broadband providers	4
Has a definition for “advanced services”	2
Regulates broadband service-quality	2
Sets rates for broadband services	0

Note: Number of states includes the District of Columbia.

Source: Derived from California Public Utilities Commission (2005).

Table 2

Broadband Penetration and Government Policies

All policy variables included simultaneously

	Broadband per capita		
	Total	ADSL	Cable
Telecom companies guaranteed access to rights-of-way	0.006	0.002	0.002
	(3.01)**	(1.48)	(1.16)
Cable companies exempt from state rights-of-way regs	-0.009	0.001	-0.015
	(2.44)*	(0.32)	(3.43)**
State limits municipal deployment of broadband services	-0.003	-0.001	-0.003
	(1.53)	(0.53)	(1.30)
State uses universal service mechanisms to attract broadband deployment	-0.006	0.002	-0.006
	(2.15)*	(1.18)	(2.24)*
State offer private-sector grants targeted to deployment in underserved areas	-0.010	-0.004	-0.006
	(2.93)**	(1.52)	(1.92)+
State offers private-sector loans targeted to deployment in underserved areas	-0.003	0.000	-0.006
	(0.60)	(0.10)	(1.14)
State offers private-sector grants targeted to deployment in rural areas	0.011	-0.002	0.021
	(2.29)*	(0.57)	(3.49)**
State offers tax incentives to broadband providers	-0.003	0.002	-0.005
	(0.95)	(0.94)	(1.41)

Share UNE lines	-0.002	-0.037	0.012
	(0.05)	(1.69)+	(0.35)
Share CLEC resold lines	0.344	0.136	0.197
	(3.57)**	(1.92)+	(1.53)
Population	0.000	0.000	-0.000
	(0.14)	(1.64)	(3.07)**
Share state's population urban	0.072	0.050	0.041
	(7.26)**	(7.13)**	(2.64)*
Republican governor	-0.004	-0.004	0.000
	(2.01)*	(3.00)**	(0.18)
Median household income	0.001	-0.000	0.001
	(2.52)*	(1.58)	(2.78)**
Venture capital per capita	-0.004	-0.005	0.002
	(0.74)	(1.15)	(0.33)
Constant	-0.032	-0.012	-0.026
	(3.66)**	(1.89)+	(2.69)**
Observations	133	112	94
R-squared	0.89	0.74	0.84

Absolute value of t statistics in parentheses

+ significant at 10%; * significant at 5%; ** significant at 1%

Year fixed effects included in all regressions

Table 3
Broadband Penetration and Government Policies
Each policy variable included separately

	Broadband per capita			Broadband per capita			Broadband per capita			Broadband per capita		
	Total	ADSL	Cable	Total	ADSL	Cable	Total	ADSL	Cable	Total	ADSL	Cable
Telecom companies guaranteed access to	0.004	0.000	0.003									
rights-of-way	(2.12)*	(0.09)	(1.27)									
Cable companies exempt from state rights-of-	-0.004	-0.001	-0.002									
way regs	(1.22)	(0.66)	(0.61)									
State limits municipal deployment of				-0.001	-0.001	0.001						
broadband services				(0.60)	(1.11)	(0.52)						
State uses universal service mechanisms to							-0.004	0.001	-0.004			
attract broadband deployment							(1.25)	(0.53)	(1.38)			
State offer private-sector grants targeted to										-0.001	-0.002	0.001
deployment in underserved areas										(0.33)	(1.91)+	(0.55)
State offers private-sector loans targeted to												
deployment in underserved areas												
State offers private-sector grants targeted to												
deployment in rural areas												
State offers tax incentives to broadband												
providers												
Share UNE lines												
Share CLEC resold lines												
Population	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000
	(1.09)	(0.39)	(2.01)*	(0.75)	(0.44)	(2.10)*	(0.57)	(0.38)	(2.28)*	(0.73)	(0.85)	(2.11)*
Share state's population urban	0.055	0.040	0.052	0.057	0.039	0.044	0.056	0.039	0.044	0.056	0.038	0.044
	(6.12)**	(7.10)**	(3.36)**	(6.35)**	(7.34)**	(2.91)**	(6.32)**	(7.27)**	(2.91)**	(6.23)**	(7.23)**	(2.90)**
Republican governor	-0.005	-0.004	0.001	-0.004	-0.004	0.002	-0.004	-0.004	0.002	-0.004	-0.004	0.001
	(2.25)*	(3.21)**	(0.48)	(1.92)+	(3.27)**	(0.69)	(1.94)+	(3.39)**	(0.83)	(1.95)+	(2.97)**	(0.60)
Median household income	0.001	-0.000	0.000	0.001	-0.000	0.000	0.001	-0.000	0.001	0.001	-0.000	0.001
	(3.63)**	(0.60)	(2.05)*	(3.29)**	(0.67)	(2.09)*	(3.48)**	(0.89)	(2.58)*	(3.27)**	(0.47)	(2.20)*
Venture capital per capita	0.001	0.002	0.004	0.001	0.002	0.006	0.000	0.003	0.003	0.001	0.000	0.006
	(0.21)	(0.40)	(0.60)	(0.14)	(0.46)	(0.89)	(0.02)	(0.77)	(0.56)	(0.18)	(0.03)	(0.93)
Constant	-0.027	-0.010	-0.027	-0.024	-0.009	-0.023	-0.028	-0.008	-0.027	-0.024	-0.009	-0.024
	(3.81)**	(2.11)*	(3.13)**	(3.35)**	(2.00)*	(2.64)**	(3.56)**	(1.60)	(2.96)**	(3.30)**	(2.01)*	(2.66)**
Observations	192	138	106	196	142	110	196	142	110	196	142	110
R-squared	0.79	0.63	0.70	0.78	0.64	0.68	0.78	0.63	0.69	0.78	0.64	0.68

Absolute value of t statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Year fixed effects included in all regressions

Table continued

Table 3 (continued)
Broadband Penetration and Government Policies
Each policy variable included separately

	Broadband per capita			Broadband per capita			Broadband per capita			Broadband per capita		
	Total	ADSL	Cable	Total	ADSL	Cable	Total	ADSL	Cable	Total	ADSL	Cable
Telecom companies guaranteed access to rights-of-way												
Cable companies exempt from state rights-of-way regs												
State limits municipal deployment of broadband services												
State uses universal service mechanisms to attract broadband deployment												
State offer private-sector grants targeted to deployment in underserved areas												
State offers private-sector loans targeted to deployment in underserved areas	-0.003	-0.002	0.001									
	(1.27)	(1.46)	(0.22)									
State offers private-sector grants targeted to deployment in rural areas				0.002	-0.002	0.006						
				(0.86)	(1.94)+	(2.57)*						
State offers tax incentives to broadband providers							-0.004	-0.001	0.001			
							(1.79)+	(0.87)	(0.51)			
Share UNE lines										0.005	-0.041	0.035
										(0.13)	(2.06)*	(1.06)
Share CLEC resold lines										0.434	0.111	0.486
										(4.47)**	(1.79)+	(4.12)**
Population	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	-0.000
	(0.84)	(0.52)	(2.05)*	(0.44)	(0.73)	(2.52)*	(0.82)	(0.37)	(2.09)*	(0.71)	(0.62)	(1.78)+
Share state's population urban	0.056	0.039	0.044	0.056	0.040	0.042	0.056	0.039	0.044	0.077	0.052	0.024
	(6.26)**	(7.26)**	(2.87)**	(6.32)**	(7.54)**	(2.87)**	(6.39)**	(7.32)**	(2.89)**	(7.25)**	(7.77)**	(1.54)
Republican governor	-0.004	-0.004	0.002	-0.004	-0.004	0.000	-0.004	-0.004	0.002	-0.006	-0.005	0.000
	(1.86)+	(3.24)**	(0.72)	(2.12)*	(3.05)**	(0.21)	(1.84)+	(3.29)**	(0.72)	(2.70)**	(4.03)**	(0.17)
Median household income	0.001	-0.000	0.001	0.001	-0.000	0.001	0.001	-0.000	0.001	0.000	-0.000	0.000
	(3.39)**	(0.66)	(2.20)*	(3.24)**	(0.68)	(2.54)*	(3.15)**	(0.81)	(2.23)*	(0.49)	(1.75)+	(1.43)
Venture capital per capita	0.001	0.002	0.005	0.002	0.000	0.009	0.001	0.002	0.005	0.002	-0.002	0.004
	(0.14)	(0.45)	(0.82)	(0.37)	(0.12)	(1.46)	(0.17)	(0.56)	(0.86)	(0.26)	(0.47)	(0.61)
Constant	-0.024	-0.009	-0.023	-0.024	-0.010	-0.026	-0.022	-0.008	-0.024	-0.022	-0.014	-0.011
	(3.37)**	(1.94)+	(2.58)*	(3.34)**	(2.11)*	(3.07)**	(3.06)**	(1.83)+	(2.65)**	(2.49)*	(2.38)*	(1.22)
Observations	196	142	110	196	142	110	196	142	110	137	116	98
R-squared	0.78	0.64	0.68	0.78	0.64	0.70	0.78	0.64	0.68	0.86	0.71	0.77

Absolute value of t statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Year fixed effects included in all regressions

Table 4
Policies and Rural Broadband Availability

	Change in the number of rural residents living in zip codes with at least one broadband provider							
Telecom companies guaranteed access to r.o.w	9979 (0.95)	9293 (0.92)						
Cable companies exampt from right of way regs	31836 (1.86)+	13821 (0.96)						
State limits municipal deployment of broadband services	12720 (1.17)		9342 (0.92)					
State uses universal service mechanisms to attract broadband deployment	12338 (0.94)			5,041.66 (0.38)				
State offers private-sector grants targeted to deployment in underserved areas	-22436 (1.17)				-7049 (0.65)			
State offers private-sector loans targeted to deployment in underserved?	23048 (1.03)					5133 (0.48)		
State offers private-sector grants targeted to deployment in rural areas	-15151 (0.62)						-1627 (0.15)	
State offers tax incentives to broadband providers?	-7626 (0.46)							1464 (0.15)
USDA Rural Development Telecommunications program less broadband spending ($000)	**0.63 (2.96)****	**0.70 (3.36)****	**0.69 (3.29)****	**0.70 (3.32)****	**0.71 (3.38)****	**0.71 (3.40)****	**0.72 (3.39)****	**0.71 (3.39)****
USDA Rural Development broadband program ($000)	**0.51 (0.66)**	**0.55 (0.74)**	**0.51 (0.68)**	**0.55 (0.72)**	**0.66 (0.88)**	**0.57 (0.77)**	**0.61 (0.81)**	**0.59 (0.79)**
Share UNE lines	56180 (0.33)	2793 (0.02)	90439 (0.58)	89511 (0.56)	84373 (0.54)	74222 (0.47)	85890 (0.53)	77927 (0.49)
Share CLEC resold lines	-218408 (0.45)	-467145 (1.05)	-395572 (0.88)	-418127 (0.92)	-373437 (0.82)	-430311 (0.95)	-389978 (0.83)	-415652 (0.91)
Share state's population urban	-88359 (1.76)+	-90743 (1.86)+	-72336 (1.49)	-68111 (1.41)	-65635 (1.35)	-66833 (1.38)	-67357 (1.38)	-67763 (1.40)
Republican governor	-1180 (0.11)	-3619 (0.35)	-3455 (0.34)	-3153 (0.31)	-1087 (0.10)	-3772 (0.36)	-2614 (0.25)	-2870 (0.28)
Median household income	-809878 (0.67)	1220 (0.00)	-396766 (0.38)	-413176 (0.37)	-211452 (0.21)	-246185 (0.24)	-271495 (0.26)	-224301 (0.22)
Venture capital per capita	8627436 (0.15)	11668310 (0.22)	-820958 (0.01)	-4475378 (0.08)	-20810000 (0.37)	-9438282 (0.17)	-12600000 (0.23)	-10780000 (0.20)
Rural population	0.034 (4.63)**	0.032 (5.02)**	0.028 (4.31)**	0.03 (4.66)**	0.031 (4.62)**	0.029 (4.50)**	0.03 (4.66)**	0.029 (4.64)**
Constant	109796 (2.01)*	85020 (1.76)+	92846 (1.89)+	91010 (1.78)+	81509 (1.67)+	84630 (1.75)+	85193 (1.76)+	83588 (1.69)+
Observations	103	103	106	106	106	106	106	106
R-squared	0.61	0.58	0.55	0.55	0.55	0.55	0.55	0.55

Absolute value of t statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Year fixed effects included in all regressions

Figure 1

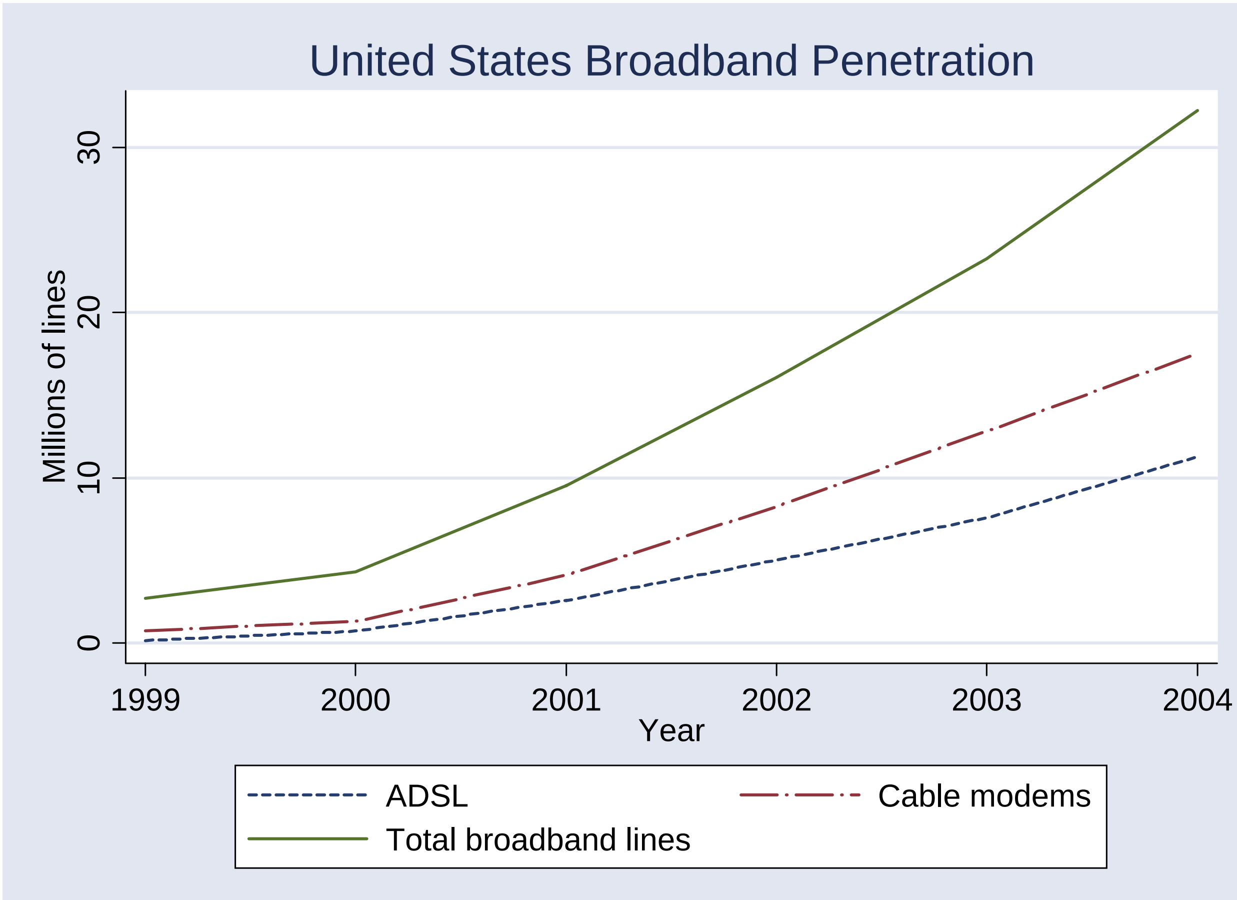
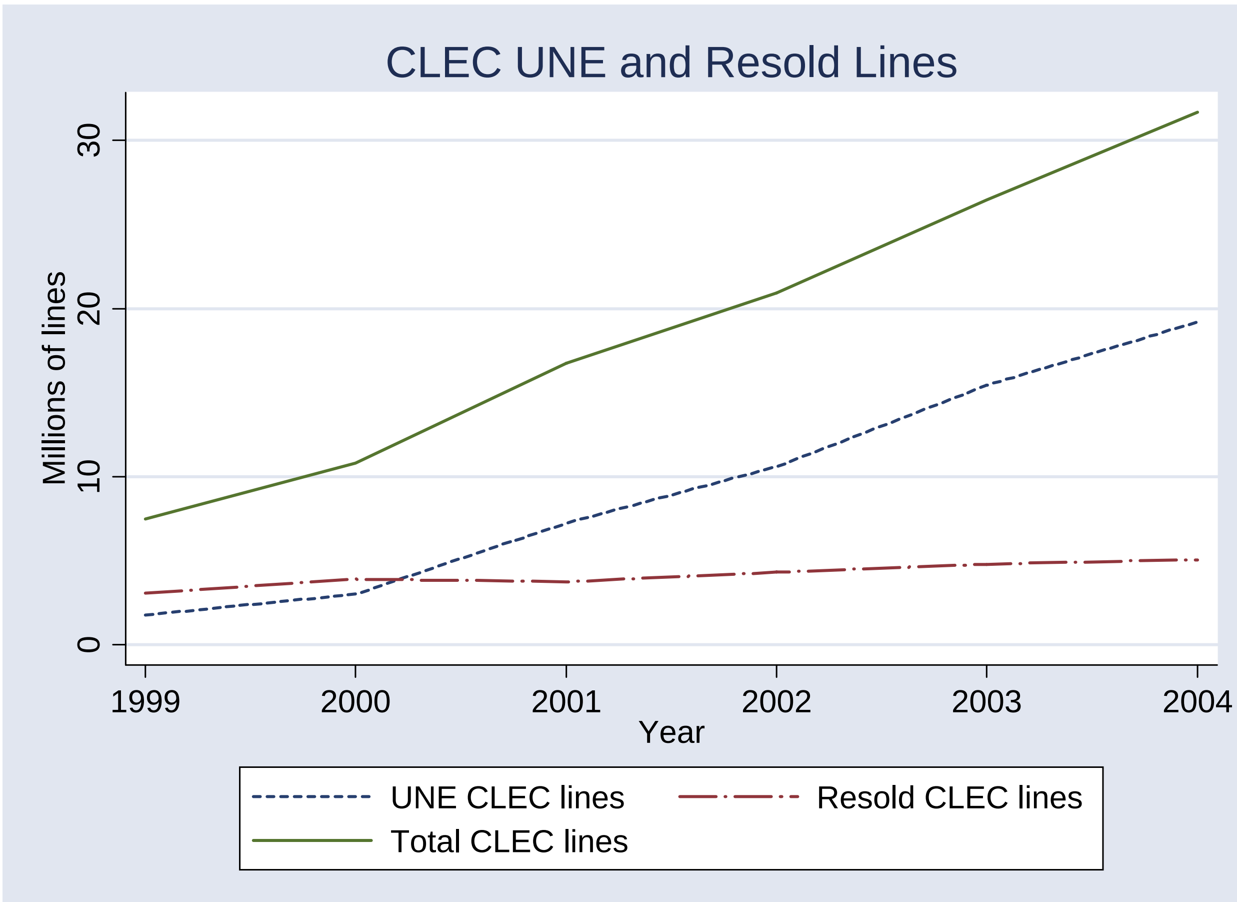

United States Broadband Penetration
Millions of lines
0
10
20
30
1999
2000
2001
2002
2003
2004
Year
ADSL
Cable modems
Total broadband lines

Figure 2


CLEC UNE and Resold Lines
Millions of lines
0
10
20
30
1999
2000
2001
2002
2003
2004
Year
UNE CLEC lines
Resold CLEC lines
Total CLEC lines

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