Availability of Broadband Internet Access: Empirical Evidence

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Abstract

Broadband access is needed for the Internet to achieve its full potential, and how these services are offered is likely to have important implications for the extent of competition for communication services in the last mile. This paper describes a research project of the MIT Internet & Telecoms Convergence Consortium (ITC)[1] into local Internet access and presents initial results from our empirical survey of the patterns of deployment for broadband Internet access in the United States, focusing on xDSL and cable modems as the two technologies that have been deployed most extensively to date. We were unable to find much evidence of residential xDSL deployments through the end of 1998; however, we did identify over 805 communities where cable modem services are now available. The demographics of these communities suggest that to date that these services are still not widely available, and where available, are concentrated in higher income, higher density markets -- as might be expected for a new technology. Moreover, when broadband access is available, consumers are unlikely to face competitive alternatives for providers. And, finally, the identity of the cable television provider has had an important impact on the likelihood that cable modems will be available. We suspect this result reflects differences in strategic decisions based on differing views of the attractiveness of broadband services and earlier decisions on the timing and extent of system upgrades. For example, MediaOne has been substantially more aggressive in deploying cable modem services than have carriers with typically lower-quality outside plant, such as Cablevision and TCI. While these results are not surprising, they are nevertheless important in helping to establish a baseline for continued research and in suggesting additional data requirements and questions that need to be examined to more fully understand the evolution of Internet access. In addition to the empirical data presented, we describe our future research agenda.

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[1] This research has been sponsored by the MIT Internet and Telecoms Convergence Consortium, a multi-disciplinary, joint industry-academic research effort to study the economic, technical, business, and policy issues that arise as a consequence of the convergence of telecommunications and the Internet. For further information, see http://itel.mit.edu.

I. Introduction

The Internet's importance in our communications infrastructure and as a platform for electronic commerce continues to grow. Already, over 26% of U.S. consumers have Internet access from their homes[2], while Internet applications and services continue to evolve and expand into areas served by other media, such as telephony and broadcasting. A recent report from the University of Texas estimates that the Internet accounts for $301.4 billion in revenues from associated businesses and 1.2 million jobs.[3]

Today, most consumers access the Internet over relatively low-speed dial-up connections. In most cases, this means that residential consumers are limited to data rates of from 28.8 Kbps to 56 Kbps for standard analog modems and 128 Kbps for ISDN services. Furthermore, additional delays and inconvenience result from the need to establish a dial-up connection each time an Internet session is established (*e.g.*, to check email or browse the Web).

For the Internet to realize its true potential as a platform for global communications infrastructure supporting integrated, interactive multimedia services, consumers will need "always on"[4] broadband access. Although there is no general agreement as to what precisely constitutes broadband access, we take it to mean access at rates that will support the kind of user experience many employees see when they are at work[5], or substantially faster than what can be provided over ISDN.[6] A broadband

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[2] According to the NTIA (1999), 26.2% of U.S. homes had Internet access in 1998, up from 18.6% in 1997 (see Chart I-1). The same report indicates that 22.2% of persons in the U.S. had Internet access from the home and 32.7% had access from any location (home or work) in 1998 (see Chart II-1).

[3] See Barua, Pinnell, Shutter, and Whinston (1999).

[4] "Always on" access is important because it facilitates push technologies, whereby content and applications can be sent from the network, or "pushed" directly to the consumer (*e.g.*, a telephone call or news updates). In addition, an "always on" connection eliminates the delay associated with establishing a dial-up connection, which enhances usability.

[5] Most employees access the Internet over their LAN connection, which in many cases is a shared 10 Mbps Ethernet network. Congestion on the shared LAN or on the connection link from the LAN to the Internet, firewalls, or limitations of the users' application software or customer premise equipment can substantially reduce the effective bandwidth (or, equivalently, increase the delay) available to employees in work environments.

[6] A number of ISPs currently offer dial-up ISDN connections at 64Kbps or 128Kbps.

connection allows users to download Web pages and files more quickly and facilitates new applications such as streaming audio/video and interactive services such as video conferencing and Internet telephony.[7]

Broadband Internet access also has important policy implications. First, if the Internet is successful in realizing its full potential, then telecommunications policy-makers will need to broaden their definitions of universal service to include Internet services. Second, the Internet can help facilitate competition among alternative physical infrastructure networks (*e.g.,* wireline telephone networks, electric utility power lines, cable television cables, or wireless networks).[8] While today, the Internet is largely an application that runs on top of the telephone network, in the future, telephony will be one of many applications provided over the Internet. This is especially important in light of the trend towards liberalization and competition, with an increased reliance on market forces to assure efficient provisioning and pricing of telecommunications services.

Today, dial-up access is broadly available in the United States and is quite competitive. Most consumers have a choice of several providers from which to obtain such access and the prices charged for such access services are close to cost.[9] According to Downes and Greenstein (1999), over 70% of potential subscribers live within a local telephone call of five or more competing providers of Internet access services; however,

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[7] For example, a 2MB video clip file will download in approximately:

Technology	Time to Download 2MB file
14.4 Kbps modem	18 minutes
56 Kbps modem	5 minutes
128 Kbps ISDN line	2 minutes
10 Mbps cable modem	0.2 seconds

[8] See Lehr and Kavassalis (1999) and Clark (1999) for discussions of how the Internet promotes increased competition among communications service providers, and Lehr and Kiessling (1998) for a discussion of some of the policy implications for global regulators due to the rise of the Internet.

[9] See McKnight and Leida (1998). This analysis focuses on the incremental costs of an Internet Service Provider who leases facilities from the local telephone company and so does not address the question of whether the prices for leased transport services are priced at cost.

all of these providers rely on the existing wireline infrastructure of the local telephone company to connect to their subscribers in the last mile. Although narrowband wireless alternatives to local telephone lines are becoming more widely available, these typically offer lower quality service than can be obtained from existing dial-up service providers. The real competition for Internet access in the future is likely to be for broadband services both because of the maturation of Internet services requiring higher data rates and because of the way in which alternative facilities-based providers are likely to compete.

Broadband Internet access services will enable service providers to offer a wider range of bundled communications services (*e.g.,* telephone, Web Access, email, Internet video, etc.) and will increase the extent of competition among existing physical infrastructure providers. There is a general belief among industry participants that consumers would prefer to purchase integrated services from a single provider (*i.e.,* controlling for quality and price differences) and, because of scope economies, marketing costs are likely to be lower for bundled services -- allowing such offerings to be offered at a discount relative to a la carte offerings.[10] Indeed, bundling is often employed as a means for implementing price discrimination policies.

While broadband access will be important for the evolution of the Net and of competition for local access communications services, it is unclear how many broadband providers can survive in each market, and how vigorously they will compete if there are only two. If local access facilities remain a bottleneck, then it may be necessary to require regulatory unbundling. In the case of local telephone facilities, the Telecommunications Act of 1996 already requires such unbundling by the Incumbent Local Exchange Carriers (ILECs, *e.g.,* Bell Atlantic, BellSouth, GTE, etc.). The Act, however, often seems to equate "telecommunication services" with "telephony," and so does not adequately address the requirements of assuring adequate broadband access. Meanwhile, the FCC is resisting pressure from AOL, local telephone companies, and some local regulatory

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[10] There are also scope economies associated with sharing network facilities for multiple services; however, it is possible for multiple retail service providers to offer competing service bundles over the same shared facilities.

authorities and user groups to require AT&T to unbundle Internet access over its soon-to-be acquired cable television facilities (*i.e.,* TCI and MediaOne).[11]

Therefore, the availability and extent of competition for broadband Internet access services is of great interest to both industry analysts, policy-makers, and Internet-promoters alike. There are a number of important questions that need to be addressed, including:

- How much will consumers be willing to pay for broadband access?
- What services will providers offer and consumers desire over broadband access?
- How much will it cost to deliver such access? For the carriers? For the service providers? For consumers?
- What will be the industry structure for broadband access services?
- How close substitutes are alternative technologies?
- Will there be an even larger "digital divide" for broadband access then exists for narrowband access?
- If competition is inadequate, should policy-makers intervene, and if so, how?

While our long range research goal is to explore these and other questions related to the evolution of Internet access, we have started with an empirical study of the patterns of deployment of broadband Internet access, primarily in the U.S where the main technologies used to provide broadband Internet access have been cable modems and xDSL. Our goal in this paper is twofold: (1) to present initial results of our survey of cable modem services in the U.S.; and (2) to describe our future research plans and efforts within the MIT Internet and Telecoms Convergence Consortium.

As of July 1999, we find that residential xDSL deployments have been quite limited to date. However, using a variety of publicly available sources, we have found 781 U.S. communities with cable modems deployed through July 1999.[12]

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[11] See Oxnan (1999), FCC's Advanced Telecommunications Capability/S706 Report, and FCC (1999).

[12] Of these, 22 have multiple systems so there are 805 observations in our data set for which we have demographic data. Some of the communities are quite large (*e.g.,* Philadelphia, PA) and so evidence of multiple systems does not mean that consumers can choose among multiple providers because the systems may not overlap.

Rolling these communities up to the county level to match them with demographic data from the U.S. census, we find that population is the strongest predictor of the presence of cable modems. Of the 100 most populous counties in the U.S., at least 69 have cable modems. As Table 1 indicates, cable modem deployments reflect the effect of market forces. The 232 counties we have found with cable modem deployments to date represent under 10% of U.S. counties but 43% of the U.S. population, and are, as expected, more affluent than average and have a much higher population density[13].

<<Insert Table 1>>

It is understandable that service providers have focused first on the largest potential markets. Moreover, some carriers such as MediaOne have been noticeably more aggressive in deploying modem services than other carriers such as TCI. This may be true in part because of systematic differences in the quality of different carrier's outside plant (which may be due either to the selection of markets they are in or to past investment decisions regarding plant upgrades), or due to differing views about the prospects for broadband Internet services. This heterogeneity in deployments may be due simply to the early stage of market development and we may see other carriers catching up and deployments spreading to other markets. Certainly, the pace cable modem deployments has accelerated (the bulk of our observations are from 1998) and announcements by telephone companies of planned or new xDSL deployments indicates that in a number of markets, customers will be able to choose among at least two alternative providers for broadband services. While these signs are encouraging, it is clear that today competition is limited and access to services is far from universal. It is still too early to conclude that competition will be adequately robust in the future and that all communities will be served. We view these results as most interesting for the questions they help prepare us to address and in providing a baseline against which to compare future developments and assess trends. This is only the first step in a more extensive examination of the evolution of Internet access.

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[13] Per-subscriber costs are lower for deploying distribution facilities in more dense areas. See Gillett (1995).

The balance of this paper is divided into four sections. Section II briefly reviews alternatives for broadband access in the United States. Section III discusses our data collection efforts and describes the data, explaining why we focused on cable modem deployments in the present study. Section IV presents our data analysis. Section V offers conclusions and future directions for research.

II. Broadband Access Alternatives

As we explained in the introduction, there is no single definition of what constitutes broadband Internet access. From a policy perspective, such a definition is important both for assessing whether particular technology deployments should be considered competitive broadband alternatives, and for assessing progress toward universal broadband availability.

Defining broadband remains an open question which we will be addressing as part of the ongoing ITC research agenda. For the purpose of this paper, we focus on three essential features that we believe are important:

- *Always on connection*: This is important both for general usability and for particular types of new services. "Always on" eliminates the delay and hassle of having to establish a connection, particularly important when users wish to access the Internet in small doses, *e.g.* to check weather or traffic. It also facilitates the delivery of new services requiring a "push" capability such as notification of incoming email or a telephone call, or automatic receipt of content from advertisers or information providers.
- *Broadband both directions*: While Web browsing is substantially enhanced by expanding only the downlink, a limited uplink does not offer symmetric broadband services. We believe these are likely to be important as consumers become the sources of more content (*e.g.,* digital pictures attached to emails, Web video conferencing, interactive games, etc.). Generally, we focus on services that are capable of delivering speeds faster than dialup or ISDN (64-128 Kbps) in each direction.[14]
- *Internet access*: The service should provide access to standard Internet services (email, web browsing, telnet, and FTP services). It should not restrict the user's ability to access other sites or services provided on the global Internet.

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[14] The data sets described below, however, also include the small number of cable modem deployments that use dial-up telephone lines instead of the cable plant for transmission in the upstream direction.

A number of technologies can be used to provide broadband access over different local distribution facilities. Such facilities include the copper wire plant of the telephone companies, the fiber and coaxial cable CATV networks of the cable television operators, the electric power lines of the utilities, and a variety of wireless alternatives (*e.g.,* satellite, mobile wireless, or fixed wireless). Each of these platforms offers different technical and market challenges, such that the services offered over the different platforms are not perfect substitutes.

In this paper, we ignore services provided over electric utility transmission lines because these are still too new and not widely deployed in the U.S.. Similarly, we ignore wireless alternatives because these either do not meet our criteria for broadband access (*i.e.,* they do not support high-speed access in both directions) or are too new or not available yet.[15]

The chief candidate for providing access over the telephone network is digital subscriber line (xDSL) , where the "x" refers to the fact that this technology comes in many flavors.[16] xDSL services support high speed data transmission over regular twisted-pair copper telephone lines in the last mile. Services offering data rates of up to 1 Mbps upstream and up to 8 Mbps downstream are now commercially available. Called asymmetric DSL (ADSL), such services can support the delivery of high quality video over the local telephone loop plant; in fact, they were first developed as a technology to allow telephone companies to offer television services. The data rates offered by DSL services vary tremendously, depending on both technical factors (*e.g.,* the shorter the subscriber's loop, the faster the potential data rate) and marketing-related decisions (*e.g.,* phone companies may price higher-speed services out of the range of residential

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[15] Mobile wireless options are usually limited to low data rates and are sold principally to subscribers seeking mobility instead of higher data rate access. Satellite services offer an asymmetric connection with only a narrowband channel from the subscriber to the Internet. For example, DirecPC from Hughes provides high speed, asymmetric Internet access with downloads at up to 400 Kbps and uploads via a dial-up modem; it has achieved very little market success. Other more promising wireless options are under development (*e.g.,* fixed broadband wireless such as LMDS or MMDS), but commercial deployments are still quite rare..

[16] In addition to xDSL, there are a host of dedicated private line services that are offered to commercial customers (*e.g.,* variable rate data lines such as T1 or burstable T1 lines). As competition for commercial data services intensifies, the prices for these services have been falling, raising the possibility that in the future services targeted at commercial customers may become attractive to residential consumers.

customers, so as not to cannibalize profitable business services). Common options at the time of this writing include both symmetric and asymmetric offerings, with data rates ranging from as low as 256 Kbps in each direction, to more than 25 Mbps downstream for VDSL.[17] Regardless of the flavor or data rate, DSL is a point-to-point technology, meaning that all the bandwidth on a subscriber's loop is always dedicated to that subscriber.

Cable modems are the chief candidate for providing access over local CATV distribution networks. These provide subscribers with a LAN connection, in theory offering performance comparable to traditional office Ethernets. While cable modem technology can typically support data rates of 10 Mbps downstream and either the same or less upstream, service providers equally typically invoke management software to constrain the amount of bandwidth, especially in the upstream direction where spectrum is more limited, that any single customer can consume. Unlike the point-to-point nature of DSL technology, cable LANs are shared, meaning that customers can burst (*i.e.*, momentarily transmit) data at rates up to 10 Mbps downstream, but that average data rates measured over longer time periods depend on how many other users are transmitting data simultaneously.[18]

The effect of sharing on performance as seen by the end user is not unique to cable modems, however. Even with DSL – or dial-up for that matter – users may experience performance degradation caused by excessive sharing in parts of the network beyond the last mile. Such parts include Web servers, backbone networks, and service providers' links to backbone networks. Because the overall end-user experience is determined by the weakest link in the chain, broadband access does not always guarantee satisfactory performance. Anecdotally, however, the experience of most cable and DSL users has been quite positive, at least in the U.S. where backbone network capacity is reasonably plentiful.

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[17] VDSL=Very high-speed DSL. See http://www.cabledatacomnews.com/sep99/sep99-3.html for more information about a VDSL offering in Phoenix. The higher frequencies and bit rates of VDSL are possible in geographic areas where the telephone lines are buried (reducing unintentional radiation problems) instead of strung on aerial poles.

[18] See (Gillett, 1995) for more detail on cable modem and DSL technologies.

While cable modems and xDSL services are broadly capable of supporting similar sorts of broadband access, they are not perfect substitutes (Table 2 summarizes some important differences, and includes satellite access for an additional comparison). First, cable modems are a more mature technology. Standardization is substantially further advanced, not only for modem technology, but also for service offerings and deployment practices. In principle, the basic coaxial cable media used in the last segment of the network offers more bandwidth than the copper loop; however, it is not clear how important this will be in practice because of sharing of the cable and because of the ability to deliver quite high data rates over copper if the distance is short enough (*i.e.*, extending fiber to the curb and putting electronics closer to the household in remote terminal units). A more important limitation on DSL is how difficult it may prove to offer as a mass market service: the high degree of heterogeneity found in existing copper loop facilities may require an expensive truck roll for every customer (not good for DSL's economic model), as well as causing performance to vary from one customer to another (a marketer's nightmare).

A second important difference is in how providers have chosen to position these services. Typically, cable modems have been positioned as a consumer product. In contrast, xDSL services have been initially more targeted at small businesses, especially when offered by non-ILEC service providers (*i.e.*, CLECs and ESPs). The business offerings are priced higher and often offer additional services such as multiple IP addresses,[19] Website support, and disk storage.

A third important difference arises from the fact that each of these technologies is associated with a particular set of industry participants. Among the general public, cable television operators have a poorer reputation for service quality than telephone carriers. On the other hand, broadband Internet access is a new type of service, with new opportunities for brand and reputation establishment. Regardless of industry affiliation, different operators may choose to position their services differently, depending on

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[19] This makes it easier for multiple user terminals to share the xDSL link over a LAN.

strategic business decisions and the regulatory environment. We hope in future research to investigate the implications of such differences.

III. Data and Methods

As with any empirical analysis, an investigation of broadband service availability necessarily depends on what data can actually be obtained. In this section, we first discuss the analyses that would ideally be performed if all desired data were (a) already collected and (b) accessible to an academic researcher. We then describe the actual data that we were able to collect, what assumptions we made in working with these data, and what kinds of analyses we were able to perform.

Ideally, research into broadband availability would be based on the following information and analyses:

- In which locations is broadband deployed – and by which service providers – and in which locations is it not? Ideally, this information would be collected for every broadband technology, including cable modems, DSL, and wireless technologies. From these data, a map could be constructed showing the extent of broadband availability and competition (*i.e.*, how many and which areas have access to zero, one, or more than one competing broadband service?). These data could also be used to test the hypothesis of "provider push," namely, that broadband deployment locations are determined more by the service areas of the most aggressive infrastructure providers than by "demand pull," or in other words the attractiveness of particular areas' demographics.
- What regulatory approach applies in each of these locations? Approaches may vary at the national, state, and in some cases local level (cable franchises, for example, are negotiated by local communities). From this information, it could be determined whether particular regulatory approaches are a significant factor in determining which locations have broadband.
- What are the demographic characteristics of the locations that do and don't have broadband? Basic characteristics of potential interest include income, education and population levels, as well as population density. Additional characteristics of interest include potential indicators of user demand for broadband Internet access, such as penetration rates for home PCs and dialup Internet access. [20] Such data could be used to test a "market pull" hypothesis:

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[20] The thinking here is that demand will be stronger for broadband access in locations that already support larger concentrations of narrowband Internet users. It is much easier to appreciate the virtues of high-speed, always-on connectivity when one has already experienced the World Wide Wait.

namely, that broadband will be deployed first in areas with higher socio-economic status and more Internet users.

- What are the infrastructure characteristics – cost, modernity of existing plant, supply of trained plant technicians, etc. -- of the locations that do and don't have broadband? This data could be used to test the hypothesis that idiosyncratic local conditions play a significant role in providers' determination of where to deploy broadband first.

In reality, much of the above information is not tracked at all, not tracked in geographic units small enough to be useful for this analysis (e.g. FCC telephone penetration reports give data only at the state level), or tracked by industry but not made public because of competitive sensitivities. When we began this research project in January of 1999, we (perhaps naively!) assumed that data about broadband deployment locations would be readily available for at least cable modem and DSL technologies from either government sources or market research firms. At that time, however, we found that commercial, residential DSL deployments were so rare that factual information about such deployments was considered extremely sensitive from a competitive standpoint. As a result, we elected to defer the collection of information about DSL, both because it was clear that DSL deployments were not yet a significant presence in the residential broadband market at that time, and because reliable data was prohibitively difficult to come by.

Cable modem deployments, however, proved to be much further along at that time, at least in the U.S. and Canada, and data sets close enough to what we needed were available. With help from research assistants,[21] we created our own database of cable modem deployments from 1995 through July of 1999, tagged by year of deployment, based on data from several sources. These included the Websites of cable modem industry analysts Kinetic Strategies, Inc. and GecKo Publishing; a map of cable modem deployments, current as of 1997, available from CNET; and a list of cable modem deployments available from the National Cable Television Association.[22] We were also

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[21] We gratefully acknowledge the data work done by ITC students Ozge Nadia Gozum, Abigail Hamilton, and David Pearah as well as the support and advice provided to them by ITC staffer Merrick Lex Berman.

[22] URLs for these Websites, respectively, are: www.cabledatacomnews.com; www.catv.org; www.cnet.com/Content/Features/Techno/Cablemodems/ss07.html; and www.ncta.com. We thank industry consultants Michael Harris (president of Kinetic Strategies and publisher of Cable Datacom News) and

able to extract deployment information from the Websites of several major cable modem service providers, primarily MediaOne, by automatically running a list of zip codes for the states they cover through the query engine provided on their Websites.[23] Although no one of these sources alone is exhaustive, by combining these diverse inputs, we are confident that we have a reasonably complete picture of cable modem deployments both large and small in the U.S.

The FCC proved a further source for cable industry information, supplying a database of every cable TV franchise in the U.S.[24] This database proved useful in identifying the cable television properties of the different providers, as well as identifying which communities do not have broadband. This identification relied on comparison with our self-constructed database, however, because the FCC's database does not include any information about broadband deployments. Unfortunately, although Congress has asked the FCC to track the progress of broadband (see, for example, FCC's Advanced Telecommunications Capability/S706 Report), to date they have failed to impose corresponding reporting requirements on the industry to make such detailed tracking possible.

Examination of different regulatory approaches remains outside the scope of the current study. We would expect the effect of different approaches to be most pronounced at the national level, where policy approaches and industry history vary considerably. However, to date the lion's share of commercial broadband deployments are to be found in the U.S. and Canada, making comparison with other countries problematic. With DSL

Broadband Bob (of GecKo Publishing) for providing us with textual archives of their newsletters, simplifying the task of assigning dates to deployments. When the same deployment appeared in multiple reports, we tagged it with the earliest date at which the deployment was reported to be commercially available. So, for example, if an industry newsletter in 1996 announced that a deployment was planned in town X, while CNET's 1997 map identified the same deployment as available, and a 1998 newsletter indicated that more homes had been passed as part of the same deployment, we labeled the deployment as 1997.

[23] We gratefully acknowledge ITC researcher Shawn O'Donnell for his work on this task.

[24] The FCC file contains information on cable system operators by community (see FCC, *Community Unit File Reference List as of November 7, 1998*, Cable Services Bureau (http://www.fcc.gov/csb). This database contains information that cable television providers must report to the FCC about their use of spectrum. Unfortunately, this database is not updated as frequently as the rapid ownership changes taking place in the cable industry. As a result, some post-processing of this information was required for it to be useful in this analysis.

deployments appearing on the near horizon in a number of European and Asian countries, however, it should soon become possible to investigate more rigorously the effects of different countries' policy approaches on broadband deployments.

For demographic data, we relied on two types of sources: county-level data from the U.S. census, and town-level data for the state of Massachusetts.[25] The Census, of course, provides a rich menu of demographic information. However, this information is reported at the county level. Cable modems, in contrast, are deployed at the level of the individual cable franchise, generally a much smaller geographic unit than a county.[26] In parts of the U.S. with many small municipalities (e.g. New England), cable franchises are typically awarded by town (for example, in the Boston area, Boston proper is served by Cablevision Systems Inc., while many surrounding municipalities, such as Cambridge and Newton, are served by MediaOne). In parts of the U.S. with large incorporated cities (e.g. cities in the southwestern states, such as Houston), cable franchises differ by neighborhood. As a result, the demographics of a county provide a broader brush than the demographics of an individual cable modem deployment.

Because of the difficulty of collecting demographic data at the geographic level of the cable franchise for the entire U.S., we have confined our national-level demographic comparison to the county level. However, we realize that rolling cable modem deployments up to the county level in order to match them with census data is likely to introduce some form of error. To investigate the nature of this error, we have performed a town-level demographic analysis for one state, Massachusetts.[27] The results of these analyses are reported in the Analysis of Data section below.

The problem of matching the geographic units of demographic data to broadband deployments is not unique to cable modems; it will apply to DSL as well. Since the beginning of 1999, as residential deployments of DSL have begun to accelerate, several

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[25] Data lists Massachusetts cable operators by town, with subscribership, along with demographics by town. See www.magnet.state.ma.us/dpu/catv.

[26] Nor does a cable franchise unit correspond exactly with a zip code, another popular unit for demographic analysis, particularly in private sector data. A cable franchise may span fractional or multiple zip codes.

[27] We selected Massachusetts both because the data we needed was easy to come by, and because our own familiarity with this area makes it easier to interpret data and results for this state.

companies have begun to offer Websites that tell users whether DSL is available based on their individual phone number.[28] While availability is mostly determined by capabilities at the local central office (determined by the exchange code – the first three digits of a North American phone number, after the area code), DSL availability also depends on the individual user's wire distance from that central office. Even if one were to ignore that level of detail and assume that all users of particular exchanges have DSL available to them, it is still complex to match telephone exchange codes to zip codes, town boundaries, or other indicators of cable franchise boundaries. As a result, even when DSL deployment data becomes available, it will not be a simple matter to determine accurately how many and which users actually have a choice between cable modem and DSL providers. And, as with cable modem deployments, demographic analysis of DSL deployments using Census data will have the problem that the proper unit of analysis for DSL availability is geographically much smaller than most counties.

The problem of non-matching geographic units complicated two other potential aspects of this research: additional demographic analysis, and the effects of infrastructure costs. First, we would have liked to consider not just standard demographic variables like income and population density, but also variables more closely predictive of interest in broadband Internet access, such as the household penetration rates for PCs, narrowband Internet access, or even simply second phone lines as a proxy[29]. The NTIA's series of *Falling Through the Net* surveys ask the right questions, but with a sample size that is too small to break down into counties, let alone even smaller geographic units such as cable franchise areas. A further direction for this research is to continue investigating private-sector sources of market research data that may have large enough samples to give significant results even when broken down into small geographic units.

Second, we would like to be able to control for differences in infrastructure costs. Our initial hope was to be able to use data on the costs of constructing local telephone facilities from one of the cost proxy models that have been made public in the context of the regulatory proceedings associated with implementing the Telecommunications Act of

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[28] See, for example, www.2wire.com, and www.bell-atl.com/infospeed/.

[29] We would make the assumption that second phone lines are positively correlated with Internet access.

1996. Although the single most important determinant for outside plant costs is population density (*i.e.*, average loop length), we had hoped to capture other cost differences by using estimates from the incremental cost models. To address this issue, we obtained estimates of the costs of installing local loops by wire center from an old run of the FCC's incremental cost model, however we were unable to match this successfully to a useful geographical aggregate.[30] We are still working towards finding a usable cost-proxy to include in our analysis. In the same vein, another future direction for this research is to incorporate data on the current state of cable infrastructure (*i.e.*, which cable systems have been upgraded? how many subscribers per head-end?), assuming such data proves to be publicly available.

IV. Analysis of Data

Three important conclusions emerge from an analysis of the cable deployment data. First, broadband access is far from universal. The majority of households do not currently have the option to subscribe to these services. Second, when broadband access is available, it is available in more densely populated, higher income areas. This is to be expected in light of the early stage of the market. Third, whether access is available in any particular area depends strongly on who the cable service provider is. Each of these conclusions is developed more fully below.

A. Broadband is far from universal

As we have already seen from Table 1, only 43% of the population in the US lives in counties that have at least one system offering cable modems. Because these counties are relatively large and may include multiple non-overlapping cable systems (and operators), the actual population with access to cable modems is substantially less.[31]

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[30] The geographic location of the wire center was identified by its CLLI code, a proprietary coding scheme created by Bellcore (now Telcordia). Our efforts to match these to towns, counties, or zip codes failed. We also investigated using the cost model from HAI Consulting (http://www.hainc.com/hatmodel.html). We are still considering whether this may be feasible or if there is another model that might allow us to create a cost-proxy index that we can match with our data on cable deployments.

[31] We do not have community-level population data (for the entire U.S.) to determine what share of the population by served-towns has access to cable modems. This measure would be better, but would still tend

Kinetic Strategies, a market research firm that concentrates on broadband cable, estimated that cable modems passed 26.2 million homes in the U.S. at the end of June 1999, representing 27.5% of all homes passed by cable (see Table 3).

<<Insert Table 3>>

In contrast, Downes and Greenstein (1999) found that over 87% of the population was within a local phone call of a dial-up ISP (and over 70% could choose from five or more providers).[32] While the current pace of deployments is quite rapid (see Table 4), the majority of Americans today cannot obtain broadband Internet access service from any provider, let alone have a choice among several.

<<Insert Table 4>>

However, given the limited extent of service availability and the relatively low-key way in which services have been marketed in areas where service is available, current penetration is relatively large. Of the estimated 26.2 million homes passed by cable modem systems, approximately 750,000 homes subscribed to service (average penetration of 2.8% of homes passed).[33] This suggests that at least 2.9% of the homes with Internet access have broadband access.[34]

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to overstate the availability of broadband in areas of the U.S. where providers report service in overly large geographic units. (For example, providers sometimes report that they serve cities like Detroit or Los Angeles, when in fact each of these cities has many cable franchises in different neighborhoods. The providers do not typically report the homes passed or population of the specific neighborhood they serve. This is not a problem in the Massachusetts data (see below), however, because cable franchises are typically done by towns, the same geographic unit for which population is reported in the state data.) Ideally, one would like to know the share of population (and homes) passed by systems offering cable modem service.

[32] And, if one considers dial-up access via 800 service or long distance (at a higher rate), then service is already universally available.

[33] See Table 3.

[34] That is, assuming 750,000 homes have cable modems (Kinetic Strategies), 26.2% of homes have Internet access (NTIA, 1999, Chart I-1), and there are 98.75 million homes in U.S. (Census, 1996), then 2.9% of homes with Internet access have broadband access (or, 0.029=0.75/(98.75*0.262).

B. Earliest broadband deployments go where the people and money are

As is clear from Table 1 and Table 5, initial deployments have occurred earlier in counties with larger populations, higher population densities, and higher per capita income.[35]

<<Insert Table 5>>

As we already noted, these results are not really surprising since we would expect deployments to occur first in these sorts of urban markets. First, the cost of deploying facilities is lower in more dense environments. Second, households that already own computers and have had dial-up access in the past are more likely to understand the benefits of a broadband connection and have the necessary equipment and expertise to take advantage of a cable modem. The recent NTIA (1999) study has shown that computer ownership and Internet access are higher among more affluent, well-educated households. As the Internet continues to grow in importance and as personal computers continue to get more powerful and less expensive, the potential market willing to adopt cable modems is likely to expand. This will encourage providers to deploy in a wider array of markets.

An important concern we have with interpreting the above results is that counties are too large a geographic unit to accurately reflect the deployment of cable modem services. In larger counties, there are often many systems and multiple cable operators. If any of these systems reports offering cable modem service, then we assume that everyone in the county has access to the service. In addition to the obvious error introduced because the actual coverage of systems offering modem services is smaller than the county, there may also be a measurement bias (*i.e.*, with more systems and more operators, there is a greater chance that we will have observed that modem service is offered if one or more of the operators report offering it in the county).

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[35] Table 6 provides a correlation matrix for the county demographic variables from the Census. From these it is clear the population, population density, and per capita income are all positively correlated. And, that population is very strongly positively correlated with the number of non-farm establishments and the number of houses. That is, large population counties are also more urban and have more businesses.

<< Insert Table 6>>

To test the effect of using county-level data, we computed the population means for counties with cable modems after throwing out very large counties with more than 10 system operators (see the rightmost column in Table 7). Although eliminating the very large counties reduces the mean demographic estimates, we still observe a substantial bias in favor of more populous, more dense, and higher income counties.

<< Insert Table 7>>

As a further test, we also collected data on cable modem deployments in Massachusetts to see how important it is to consider smaller demographic/geographic units. In Massachusetts, there are 351 towns, of which 309 have cable television service and, of those, 86 have cable modems. Table 8 shows that the same trends observed in the county-level national data are apparent in the more disaggregated town data, but are less significant. Towns with cable modem service have larger populations, higher per capita incomes, and higher population density -- but the differences are much less significant for Massachusetts.

<<Insert Table 8>>

For comparison purposes, Table 9 shows the county-level data for Massachusetts. Despite the small sample size, it is apparent how moving up to county-level data substantially over-estimates the share of the population served and the demographic bias with respect to the choice of counties where services are offered. According to the county-level data, only 1% of the county-population of Massachusetts is not served by cable modems -- a gross under-estimate (the corresponding town-level figure from Table 8 is 66%). In the case of Massachusetts, the problem may be accentuated because Massachusetts is densely populated and its counties have higher per capita income than the national average. The apparently reduced impact of the demographic variables may be due to a threshold effect. That is, once a community reaches a certain critical mass, *ceteris paribus*, providers find it desirable to deploy modem service. In such cases, other factors become important (*e.g.*, cost of upgrading plant at different locations, proximity to upgraded facilities in adjacent markets, special local demand conditions, etc.). To test this, we would need to see if the average town demographics in Massachusetts are systematically different from those of other communities in the U.S. and to include additional data in our analyses. We are in the process of investigating the feasibility of obtaining such data, at least for a sub-sample of areas around the U.S.

<<Insert Table 9>>

These results suggest that national county-level data remain useful for examining overall trends, but more disaggregated data is needed to more fully understand the forces driving decisions of where broadband access services are made available. Because cable modem services were deployed relatively early in Massachusetts and because of its convenient location for us, we are planning to extend our analysis of broadband access competition in Massachusetts. There are already several towns with competing providers of broadband access services (*e.g.*, MediaOne and RCN both offer services in Newton, where cable modem subscribership is reported to be unusually high -- in excess of 10% of homes passed).

C. The identity of the cable operator matters

Although higher income, more populous areas are more likely to have cable modem service, not all such areas are created equal. The likelihood that any given area will have broadband cable availability is strongly influenced by the identity of the cable provider serving that area.[36]

This result can be seen from Table 10, which lists the top 5 U.S. cable system operators in order of decreasing market share for cable television services. The comparability of the market shares in the middle two columns (percentages of cable homes passed and basic cable subscribers) indicates that the penetration of cable TV service closely parallels the size of the markets served. That is, the companies that pass the most homes also have the most subscribers. This result would seem to indicate that for cable television service, there are not large (or at least not statistically detectable)

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[36] Only a very small number of communities are served by more than one cable provider. Ironically, broadband may be the force that changes this picture: the ability to offer bundled services has induced the construction of competing cable facilities in areas with the highest broadband penetration, e.g. RCN's network in Newton, MA.

differences among the top 5 operators in terms of basic demand in the markets they serve, or their strategies for attracting and retaining customers.

<< Insert Table 10>>

This is strikingly untrue of the rightmost column of Table 10, however, showing the market share of the same top 5 operators for cable modem subscribers. Cox, for example, passes only 6% of all homes on cable systems in the U.S., yet serves 15% of all U.S. cable modem subscribers. In comparison to AT&T Broadband and Internet Services (the former TCI), which serves 21% of basic cable subscribers but only 11% of cable modem subscribers, MediaOne, Comcast and Cox have either been much more aggressive about deploying cable modems within the markets they serve, or much more successful at attracting subscribers, or both.[37]

Table 10 also illustrates a large difference in the concentration of market share for basic cable and cable modems among the other thousands of cable operators in the U.S. The top 5 U.S. operators have 57% of the cable TV subscribers, but 83% of the cable modem subscribers. This result could arise because the top 5 cable system operators disproportionately serve major urban areas, which have the most attractive demand demographics for broadband services. Alternatively, causality could run in the opposite direction: the very large, multiple-system cable operators have more technical savvy and much greater access to capital than the small, "mom-and-pop" operators that typically serve less densely-populated areas. As a result, broadband comes first to the areas served by the big operators, which happen to be the large urban areas.

Whichever the direction of causality (it cannot be determined from the data we have), smaller cable operators are starting to appear more frequently in our database, suggesting that the major operators have by now sufficiently proved the concept of broadband, paving the way for a wider scale of deployments. Still, of the thousands of cable operators in the U.S., only a hundred or so have any broadband deployments at all. Over

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[37] This result is consistent with the anecdotal reputations of the different companies: MediaOne acquired the cable properties of Continental Cablevision, which was known for investing heavily in quality plant and advanced technologies, while TCI was unloved by many customers for its lack of investment in plant and customer service. It will be interesting to observe whether such disparities disappear over time as AT&T merges TCI and MediaOne cable properties under one corporate umbrella.

the next few years, it seems likely that broadband availability will progress in three ways, depending on the identity of the cable provider:

- For the top 5 operators, new communities will continue to be added, but we expect the main thrust will be marketing to communities already served, to increase penetration levels.
- In the middle tier of operators, new communities will be added rapidly, fueled by continued consolidation (such as the many purchases of systems of this type by Charter Communications, Paul Allen's vehicle for investing in broadband cable), as well as continued evolution of backbone services aiming at this level of cable operator.
- For communities that continue to be served by very small cable operators (e.g. those that serve only 1-10 communities), we expect broadband availability to come very slowly, if at all.

V. Conclusions and Future Directions

We believe that the future of the Internet will depend on the availability of broadband access services and that competition among providers of these services will be important for the Internet, electronic commerce, and indeed, for all communications services that are supported over the last mile of our public communications infrastructure. Therefore, we need to better understand the extent and determinants of this competition. We need to know who has any form of broadband access, and of those who have access, whether they can choose among multiple suppliers. We need to know how service availability and competition are changing over time.

This paper presents results from our initial efforts to address these and other important questions about the extent to which alternative broadband access technologies offer competitive alternatives. Thus far, we have compiled a database of the communities in the U.S. where different cable operators offer cable modem service. We have linked that database to county-level demographic data and for Massachusetts, to town-level data. These data show that:

(1) Broadband access is far from universal, with only 43% of the population living in counties where cable modem service is available anywhere[38];

(2) The counties where broadband cable access is available have larger than average population, higher per capita income, and higher population density; and,

(3) There appears to be a strong cable operator identity effect, with certain operators being more aggressive in deploying cable modems.

These results are not surprising in light of the early stage of cable modem deployment, but they are useful in providing a baseline against which we can track and examine further growth. We hope to be able to extend our analysis, not only to other technologies such as xDSL, but also by including additional information to control for the costs of installing facilities, regulatory effects, additional demographic information (*e.g.*, PC home ownership and Internet usage by geographic region), and eventually, pricing data.

While we would like to extend our analysis of national trends, we are concerned that county-level data may be too coarse for an accurate assessment of the extent of availability of broadband access. However, we are not optimistic that we will be able to obtain less aggregated data on the national level, and so are considering extending the analysis in the opposite direction, looking in greater detail at a smaller region at the community-level (*e.g.*, extending our analysis of modem competition in Massachusetts). Our efforts to collect appropriate data are continuing. Given the importance of broadband to the Internet and the Internet to the economy, however, we believe that efforts to collect such data should not be limited to academic researchers; it seems a reasonable policy, and not an excessive burden on industry, to require that data about broadband deployments be disclosed to appropriate regulatory agencies, along with other information already required by governments from the telecommunications industry.

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[38] As we explain in the paper, this figure substantially overstates the share of households that have modem service available, because counties are too large a geographic entity. Kinetic Strategies estimates that approximately 27% of households have cable modem service (see Table 3).

In addition to building the empirical basis for future analysis, we believe it is important to clarify the extent to which xDSL, cable modem, and other technologies are really substitutes. These services differ in a number of important technical, operational, and market-based respects (*e.g.,* the history of the industries sponsoring each) and we are pursuing additional theoretical work within the MIT ITC to better understand these issues. This includes additional work on cost modeling, industry structure analysis, and examination of business models.

While we believe broadband access will be very important and widespread, there is still quite a bit of research that needs to be done to understand how competition for these services will evolve and to identify the best policies for promoting the continued development of the Internet. This is true not just of the U.S. but in other countries as well, especially as DSL deployments and national-level unbundling policies start to become real. We expect to continue researching these kinds of issues within the MIT ITC, and contribute a series of papers presenting results from our broadband access research efforts.

VI. References

Anitesh Barua, Jon Pinnell, Jay Shutter, and Andrew B. Whinston, "Measuring the Internet Economy: An Exploratory Study," Graduate School of Business, The University of Texas at Austin, July 1999.

Broadcasting and Cable Yearbook, 1998.

David D. Clark, "Implications of Local Loop Technology for Future Industry Structure," in *Competition, Regulation and Convergence: Trends in Telecommunications Policy Research,* S. E. Gillett and I. Vogelsang (Eds.), Lawrence Erlbaum Associates, Mahwah, NJ, 1999.

Thomas Downes and Shane Greenstein, "Do Commercial ISPs Provide Universal Access?" in *Competition, Regulation and Convergence: Trends in Telecommunications Policy Research,* S. E. Gillett and I. Vogelsang (Eds.), Lawrence Erlbaum Associates, Mahwah, NJ, 1999.

FCC, "FCC Court Brief Underscores Consumer Benefits from National Internet Policy of Unregulation -- Urges Narrow Judicial Resolution," press release, August 16, 1999 (http://www.fcc.gov).

FCC, *Report in the Matter of In the Matter of the Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996*, Before the Federal Communications Commission, Docket No. 98-146, January 28, 1999 (hereafter referred to as the "FCC's Advanced Telecommunications Capability/S706 Report")

Sharon Eisner Gillett, "Connecting Homes to the Internet: An Engineering Cost Model of Cable vs. ISDN," MIT Masters' Thesis, http://rpcp.mit.edu/Pubs/gillett_connecting_home/abstract.html, 1995.

Shane Greenstein, "Universal Service in the Digital Age: the Commercialization and Geography of US Internet Access," NBER Working Paper 6453, March 1998.

Shane Greenstein, "Building and Delivering the Virtual World: Commercializing Services for Internet Access," http://itel.mit.edu/itel/publications.html, June 1999.

William Lehr and Petros Kavassalis, "The Flexible Specialization Path of the Internet," forthcoming in *Convergence in Communications and Beyond*, E. Bohlin, K. Brodin, and A. Lundgren (Eds.), Elsevier Science, Amsterdam, 1999.

William Lehr and Thomas Kiessling, “Telecommunication Regulation in the United States and Europe: The Case for Centralized Authority,” in *Competition, Regulation and Convergence: Trends in Telecommunications Policy Research*, S. E. Gillett and I. Vogelsang (Eds.), Lawrence Erlbaum Associates, Mahwah, NJ, 1999.

Lee W. McKnight and Brett Leida, "Internet Telephony: Costs, Pricing, and Policy," *Telecommunications Policy*, Vol. 22, No. 7, pp. 555-569, 1998.

NTIA, "Falling through the Net III: Defining the Digital Divide," report from the National and Telecommunications Information Administration, July 1999, http://www.ntia.doc.gov/ntiahome/digitaldivide/.

Table 1
Demographics of cable modem deployments through June 1999[39]

	All counties	With Cable	With Modems
	Averages	Averages	Averages
Population (1995)	83,494	84,334	479,913
Houses (1990)	29,195	29,463	168,428
Nonfarm establishments (1993)	2,030	2,048	12,230
Per capita Income (1993)	16,661	16,786	20,797
Population Density[40]	214	191	757
Number of observations	3,133	3,060	232
	Sum	Sum	Sum
Population (1995, 000s)	261,586	258,063	111,340
Share of US population	100%	99%	43%

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[39] Demographic data is from the U.S. Census Bureau

[40] Per square mile.

Table 2

Comparison of Residential Broadband Access Options

	xDSL	**Cable Modem**	**Satellite**
Infrastructure	• Wireline facilities of incumbent local telephone carrier, perhaps leased by enhanced service provider	• Cable distribution plant of cable television operator.	• Satellite spectrum of direct broadcast satellite service providers.
Bandwidth	• Asymmetric • Varies, but usually capable of 1 Mbps uplink and more downstream	• Symmetric (??) • Ethernet LAN shared • In principle, higher peak rate.	• Asymmetric • Narrowband uplink (dial-up) • In principle, high downstream peak rate.
Sharing (Congestion)	• Dedicated to RTU or MDF, then shared	• Shared LAN, limits available bandwidth	• Shared downlink, limits bandwidth available to each.
Deployment costs	• Small scale (scope???) economies on network side for upgrade to existing POTS network. • 2 modems for each sub so higher marginal cost than for cable modem. • May be low cost if penetration low. At high penetration, crosstalk problems may arise.	• Large fixed cost to upgrade hub and cable distribution plant if not 2-way capable. • 1 modem per sub so lower incremental cost for cable.	• Very large fixed cost to establish satellite uplink/downlink • Bandwidth scarcity • Receiver dish for each subscriber
Other issues	• Variability of POTS plant (multiple taps, conditioning, etc.)	• Security issues on shared LAN	• Drop out, rain interference

Table 3
Cable Modem Deployment Aggregate Statistics for US and Canada

(as of 6/30/99)[41]

	U.S	Canada	Total North America
Total Cable Homes Passed	95,000,000	10,300,000	105,300,000
Cable-modem-ready homes passed	26,200,000	5,800,000	32,000,000
Cable Modem Network Availability	27.5%	56.3%	30.4%
Cable Modem Subscribers	750,000	302,000	1,052,000
Cable Modem Penetration	2.8%	5.2%	3.3%

Table 4
Deployment of Cable Systems by Year

	Number of Systems	Number of Counties Served
1996	28	19
1997	361	92
1998	354	93
1999 (through July)	62	28
Total	805	232

Table 5
Demographics for Counties with Cable Modem Service by Year of Deployment
(Averages by County)

	1996	1997	1998	1999 (through July)
Population (1995)	815,609	691,133	269,575	256,732
Population Density (per square mile)	1,171	992	577	304
Per capita Income (1993)	24,132	21,806	19,764	18,653
Homes (1990)	290,272	241,863	95,038	88,224
Non-farm Establishments (1993)	21,848	17,126	7,082	6,720
Number of systems	19	92	93	28

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[41] Estimates provided by Kinetic Strategies (http://www.kineticstrategies.com; personal correspondence with Michael Harris, president).

Table 6
Correlation Matrix for County Demographic Variables

	Pop	Pop Density	Per capita Income	Homes	Non-farm establish-ments
Population (1995)	1.00	0.36	0.30	1.00	0.97
Population Density	0.36	1.00	0.21	0.40	0.42
Per capita Income (1993)	0.30	0.21	1.00	0.31	0.35
Homes (1990)	1.00	0.40	0.31	1.00	0.98
Non-farm Establishments (1993)	0.97	0.42	0.35	0.98	1.00

Table 7
Comparison of Counties in US with and without Cable Modems

	All Counties in US	All cable modem counties	All cable modem counties with fewer than 10 cable operators
Population (1995)	83,494	479,913	271,492
Homes (1990)	29,195	168,428	96,254
Non-farm Establishments (1993)	2,030	12,230	7,053
Per capita Income (1993)	16,661	20,797	20,311
Population Density	214	757	658
Number of operators in County		6.9	4.7
Number of systems in County		31.8	21.5
Number of observations	3,133	232	187

Table 8
Demographics for Towns in Massachusetts

	Overall MA	Cable TV only	Cable modems	No cable
	Average	Average	Average	Average
Population, 1996	17,357	17,839	24,069	1,056
Per capita Income 1989	17,801	17,429	19,762	15,759
Population density	1,242	1,222	1,877	46
	Sum	Sum	Sum	Sum
Population, 1996	6,092,352	3,978,046	2,069,971	44,335
Share of population	100%	65%	34%	1%
Land (square miles)	7,839	4,877	1,714	1,249
Share of land	100%	62%	22%	16%
Number of towns	351	223	86	42

Table 9
Demographics of Counties in Massachusetts

	All Counties in MA	Counties with cable only[42]	Counties with cable modems
	(average)	(average)	(average)
Population (1995)	433,825	30,288	543,881
Homes (1990)	160,508	11,747	201,079
Non-farm establishments (1993)	11,157	978	13,932
Per capita Income (1993)	23,671	25,656	23,130
Population density (per sq mile)	1,808	109	2,272
Number of Counties	14	3	11
Total Population (1995)	6,073,550	90,864	5,982,686
Share of Population	100%	1%	99%

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[42] Every county in Massachusetts has at least one cable system.

Table 10
Market Shares for Largest U.S. Cable Operators

Operator	Homes Passed by Cable: Market Share % (#)[43]	Basic Cable Subscribers: Market Share % (#)[44]	Cable Modem Subscribers: Market Share % (#)[45]
AT&T BIS[46]	(unavailable)	21% (14.0m)	11% (83k)
Time Warner	22% (21.0m)	17% (11.7m)	25% (186k)
MediaOne	9% (8.5m)	8% (5.4m)	19% (140k)
Comcast	8% (7.4m)	6% (4.3m)	13% (95k)
Cox	6% (6.0m)	5% (3.3m)	15% (112k)
Others		43% (28.3m)	17% (134k)
Total	95,520,000	100% (67.0m)	100% (750k)

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[43] Numbers of homes passed are taken from company financial reports; market shares derived by the authors.

[44] Numbers of basic cable subscribers are taken from Broadcasting & Cable Yearbook (1998). Total number of basic cable subscribers in the U.S. comes from the National Cable Television Association (www.ncta.com/yearend98_6.html), which cites Nielsen Media Research for the figure of 67m households. Market shares are derived by the authors.

[45] Cable modem subscriber statistics are based on June 30, 1999 financial reports from the companies, as summarized by Kinetic Strategies (http://www.cabledatacomnews.com/aug99/aug99-1.html). Market shares are derived by the authors.

[46] AT&T Broadband and Internet Services, formerly TCI. AT&T's purchase of TCI's cable systems was completed in March, 1999.