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Inequities in the broadband revolution

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Abstract. Residential broadband options such as cable and digital subscriber lines are growing in popularity. However, evidence suggests that urban areas are receiving the majority of infrastructure investment, thereby leaving many rural locations with few options for broadband access. With access to telecommunication infrastructure becoming an increasingly important component to local economic development, issues of infrastructure equity are significant. This paper explores telecommunication equity and its effect on economic development by addressing the impact of geography on infrastructure investment and growth. A comprehensive database of broadband service providers and data from the Ecom-Ohio project (http://www.ecom-ohio.org), are used to explore broadband access options in the state of Ohio by examining the characteristics of market demand that are driving cable and digital subscriber line infrastructure investment. In addition, this paper develops an explanatory framework for identifying key market characteristics indicative of demand for residential broadband services through the use of statistical models and a geographic information system. Results suggest that income, education, age, location, and competition from alternative broadband platforms influence digital subscriber line infrastructure investment.

JEL classification: R0 O0 C1

1. Introduction

Residential broadband refers to a series of network technologies that promise to deliver highspeed network access to the home. By definition, the Federal Communications Commission defines *broadband* as the capability of supporting at least 200 kilobits per second (Kbps) in the consumer's connection to the network ("last mile"), both from the provider to the consumer (downstream) and from the consumer to the provider (upstream) (NTIA and RUS 2000). Unlike traditional dial-up services which operate between 28.8 Kbps and 56 Kbps, residential broadband can deliver speeds approaching 2 megabits per second (Mbps). In fact, the ability to access high-speed Internet connections from the home represents one of the most important advances in the evolving information economy (NTIA and RUS 2000). The scale of residential broadband is potentially huge in comparison to business networking (Abe 2000). For example, although there are approximately 10 million businesses in the United States, there are over 100 million households. As such, equipment providers such as Cisco and service providers such as BellSouth or SBC-Ameritech have the potential to earn millions in revenues as more homes subscribe. In addition, there is little doubt that content providers such as AOL will continue to identify revenue potential in markets such as on-demand video over the Internet, which is largely enabled by higher bandwidth connections (Murphy 2000).

There are also issues regarding the provision of residential broadband services that are of great consequence. In a recently issued report by the National Telecommunications and Information Administration (NTIA) and the Rural Utilities Service (RUS) (2000), evidence suggests that rural areas are currently lagging far behind urban areas in broadband availability in the United States. In fact, although cable modem and digital subscriber line (xDSL) technologies are making residential broadband a reality, infrastructure investment for these technologies is primarily found in urban and suburban markets. For example, 65% of the cities surveyed in the NTIA and RUS study with populations over 250,000 have both cable and xDSL broadband service. However, only 5% of the cities with populations under 10,000 have cable modem service or xDSL service available (NTIA and RUS 2000). A more specific example can be found within the state of Ohio. 46% of all counties in the state of Ohio have broadband xDSL service available in one or more locations. Of those counties classified as urban ($n = 39$), 100% have xDSL service. However, for those counties considered rural ($n = 49$), only 34% are equipped with xDSL infrastructure. The scarceness of residential broadband availability in rural areas suggests that a "digital divide" is present in the United States and the diffusion of advanced telecommunication services is not widespread. More importantly, these findings also indicate that the pro-competitive provisions of the Telecommunications Act of 1996 are not, as yet, benefiting rural and urban areas equally.

Recently, the emerging inequities in broadband Internet access have spurred legislation. The "Internet Freedom and Broadband Deployment Act", also known as the "Tauzin-Dingell Bill" seeks to solve the problems associated with broadband availability by making it easier for the local incumbent local providers (Baby Bells), to offer Internet and data services across long-distance boundaries. Currently, the Bells are not allowed to serve the long-distance marketplace without the approval of state and federal regulators. In addition, the Tauzin-Dingell Bill would also limit the line sharing requirements placed on the Baby Bells by the Telecommunication Act of 1996. The Broadband Telecommunication Act of 2002, introduced by Commerce Committee Chairman Ernest "Fritz" Hollings, proposes to use telephone excise tax revenues to offer $2 billion in low interest loans to spur the build-out of broadband services to rural areas. Further, it would offer $60 million in grants to non-profit groups to conduct planning and feasibility studies for these underserved areas.

This interest in broadband access, at both federal and local levels, highlights the growing concern of a digital divide emerging in rural America. Parker (2000) notes that access to advanced telecommunications services is important for residents and businesses in rural areas because of the massive economic transformation currently underway. In order to participate in the emerging digital economy, both businesses and households must have access to adequate connections. Malecki (2002) suggests that broadband access is growing as an essential dimension of Internet use because browsers and the graphics slow down considerably at regular dial-up speeds (28k–56k). More importantly, audio (music files and real-time radio) and video (streaming video, video conferencing, and movies on-demand) are nearly impossible to receive without a broadband connection (Malecki 2002). Thus, it is important to begin the process of identifying gaps in broadband accessibility. By doing so, one can begin to draw conclusions regarding the evolution of the digital divide, from a socioeconomic and demographic gap to a divide that reflects a combination of socioeconomic status, demographics, and *location*. In addition, gaps in broadband access also suggest a need for reevaluating current policies seeking to promote equitable investment in telecommunication infrastructure. Such gaps are indicative of the need for establishing new policies, reevaluating old policies, improving the distribution of infrastructure investment, and improving current institutional structures for the delivery of advanced telecommunication services. Finally, additional empirical testing will be helpful in the ongoing process of reevaluating the basic tenets of received theories in regional science and geography (Stabler 1999). This is particularly important in the context of the new digital economy and its shifting technologies, which have the ability to alter time-space relationships (e.g., the Internet) (Graham and Marvin 2001). For example, do telecommunications technologies impact the development of economies of scale in rural areas? How do information and communication technologies (ICT) impact our current understanding of transaction-facilitating alliances, liaisons, or contractional arrangements as they related to pools of skilled workers (Stabler 1999)? Does proximity still matter? Although these questions are important, they cannot be adequately addressed until additional empirical evidence concerning telecommunication infrastructure equity is uncovered.

Given the nature of these complex issues, the purpose of this paper is threefold. First, this paper examines several of the important telecommunications issues currently confronting the United States, including a brief review of federal policy and the impact of geography on telecommunication infrastructure investment. Second, this paper provides a current snapshot of broadband cable and xDSL service availability highlighting differences between rural and urban areas, using the state of Ohio as a case study. Third, logistic regression models are utilized for an analysis of broadband xDSL infrastructure investment in rural and urban areas. This paper concludes with a discussion of modeling results and a brief closing statement.

2. The urban-rural divide

According to the US Census Bureau, a "rural" area is defined as a town of less than 2,500 people (US Census 2000). This also includes areas outside of towns that are classified as farmland, ranchland, or wilderness. Another important aspect of rural settlement is the presence of 'rural' communities located within metropolitan statistical areas (MSA). According the Census Bureau, the majority of these communities are relatively affluent, and located close to a central city. Definitions of rurality must also be considered within the context of telecommunication services. Therefore, Egan (1996) suggests the need to distinguish between "rural" and "remote" subscribers. Remote subscribers typically experience more difficulty in gaining network access because of extreme distance or complex terrain (Egan 1996).

In a recent report, the NTIA (2000) documents household telecommunication connectivity rates in rural areas. Results indicate nearly 40% of households are connected, representing an increase of nearly 75% from 1998. Downes and Greenstein (1999) suggest, Internet service providers are nearly ubiquitous in the United States, with only 247 counties lacking an ISP. More importantly, Downes and Greenstein (1999) note that nearly 93% of the U.S. population has access to 7 or more ISPs with a local phone call. However, there are questions of service quality, options, and price that still plague rural locations. For example, Strover (2001) suggests that although Internet connectivity is available in rural locations, only the larger settlements benefit from toll-free dial-up access. This means that many rural and 'remote' subscribers are forced to pay additional long-distance tolls for dial-up Internet connectivity. Although there is the potential in certain states for households to connect outside their local calling area for Internet access, Extended Service Areas are not widely available (Allen and Koffler 1999).

The problematic aspects of rural Internet connectivity are compounded when more advanced telecommunication services are considered. As Strover (2001) notes, many rural ISPs limit their service speeds to 28.8 Kbps. Compared to the broadband services widely available in urban areas (cable and xDSL), which approach speeds nearly 8 times faster, the 28.8 Kbps connection is relatively slow. Furthermore, although telecommunication service continues to evolve, Johnson (2000) suggests rural areas will be connected, but their infrastructure and connectivity options will be more expensive and at least one generation behind urban areas.

2.1. *Universal service, natural monopolies and deregulation*

The roots of the urban/rural divide in the United States trace back to the concept of universal service. Historically, the term universal service referred to "... a telephone network that covers all of a country, is technologically integrated, and connects as many citizens as possible" (Mueller 1997, 1). This concept originated in the early 1900s, a critical time in the development of the American telecommunications system. In fact, the term was coined in the 1910 annual report by AT&T, stating, "The telephone system should be universal ... affording opportunity for any subscriber of any exchange to communicate with any other subscriber of any other exchange ... some sort of connection with the telephone system should be within the reach of all" (Tunstall 1985). Rather than simply casting universal service as a positive social goal, AT&T mentions this provision in the spirit of competition. During this timeframe, numerous independent telephone companies were battling with AT&T to become profitable providers. As such, the value of each network was directly tied to its geographic reach (Caristi 2000). By attempting to extend the reach of AT&T's network through universal service, the overall value and profitability of AT&T would be greatly enhanced. For example, Abler (1977) examined the diffusion of AT&T telephony in the U.S. from 1890 to 1904. The rapidity of AT&T service diffusion is noteworthy. In 14 years, its service region spread from a relatively small cluster of states in the northeast, to cover nearly two-thirds of the U.S.

By 1934, universal service was widely accepted as an important goal for the United States (Robinson 1989). As AT&T's network continued to grow, so too did its grip on the telecommunication industry. Pro-monopolist camps argued that true economic efficiency is only possible if one provider had all of the customers in a rural market (Selwyn 1996). In addition, the duplication of hardware and software systems to provide telecommunication service in larger urban markets is significantly less efficient than service provided by a single system. As Caristi (2000, 27) demonstrates, the combination of universal service, a natural monopoly, and the relative inefficiencies in serving rural areas created a system where a series of cross-subsidization plans were necessary for AT&T:

1. *In order to reduce the costs of providing service to rural areas, AT&T used revenues generated in higher density urban markets to subsidize their rural customers.*
2. *AT&T charged a higher cost for long distance service to keep local service lower priced.*
3. *Businesses could be charged more for telephone services than residences.*

With these types of cross-subsidization plans, it is obvious why the anti-competitive, natural monopoly was a necessity for AT&T. First, competitive carriers typically gravitate toward the most profitable segments of the industry. In this case, the most profitable segments correspond to high-density urban markets (McMahon and Salant 1999). By choosing to serve only the densest markets, a competitive carrier can offer lower rates. In effect, the competition's ability to offer lower rates squeezes AT&T out of the more lucrative urban markets and forces them to serve the less dense rural markets. This cripples the ability to cross-subsidize and ultimately limits the effectiveness of the monopoly.

Aside from the complicated structure of cross subsidy plans, anti-monopolists noted several problems with natural monopolies and the provision of telecommunication services (Egan 1996). For example, Vogelsang and Mitchell (1997) suggest that monopolist views of rural customer densities do not consider the possibility of multiple-line users in businesses and apartment buildings. Also, rather than duplicating telecommunication infrastructure, it is possible to *lease* lines from incumbent local exchange carriers to provide interconnection services.

After significant debate, anti-monopolist sentiment eventually prevailed in the United States and the telephone industry was formally deregulated with the passing of the Telecommunications Act of 1996 (TA96). The TA96 sought ways to secure lower prices and higher quality services for telecommunication systems in the United States without monopolies. Moreover, the TA96 encouraged the rapid deployment of *new* telecommunications technologies. Also of significance is the opening of local loops for competition, where the Bells were forced to make the last-mile wires available to their rivals. In this context, although business users benefit from lower priced services, the cross-subsidies that helped make rural access affordable dried up. As a result, many states are beginning the regulatory reform process to keep the costs of telecommunication services under control for both rural and urban subscribers (Duesterberg and Gordon 1997).

2.2. *Tauzin-Dingell*

It is at this juncture, nearly seven years after the passage of TA96, that the role of competition and deregulation are being reevaluated with an emphasis on broadband. As mentioned in the introduction, the Internet Freedom and Broadband Deployment Act, also known as the Tauzin-Dingell Bill, is the first significant proposal seeking to remold the TA96. One of the more controversial aspects of the Tauzin-Dingell Bill is the movement to make Bell broadband infrastructure investments exempt from the unbundling provisions of TA96 and make regulators abstain from regulating broadband services (e.g., digital subscriber lines or "xDSL") in the future. This effort to exempt Bells from unbundling their broadband infrastructure is of great concern to anti-monopolists for several reasons. Hall and Lehr (2002) suggest that removing the pro-competitive provisions of TA96 with respect to broadband would dampen the incentives for investment in broadband facilities by the incumbent local exchange carriers (Bells). Because it is not cost effective to build additional last-mile facilities (switching centers and wires) for competitive local exchange carriers (CLECs), the only opportunity for investment by Bell rivals is via existing loops. More importantly, Hall and Lehr (2002) suggest that Bells must be sufficiently restrained from extracting full monopoly value from these facilities so that rivals can afford to invest and compete. Without this competition, anti-monopolists believe that Bells will reduce their own investments in broadband infrastructure to avoid cannibalizing revenues from leased lines, second lines, and other data services to consumers (Hall and Lehr 2002; NewNetworks 2001).

Even with the long history of striving for universal service through legislation, policy, monopolies, and competition, current statistics indicate significant variations in the levels of telecommunication service penetration for the U.S. As mentioned previously, the NTIA (2000) suggests approximately 40% of rural households access the Internet. The same survey examines a more basic telecommunication service, the telephone. Today, telephones are classified as a mature technology. Simply put, telephones are common features in most American homes. Telephone penetration has stabilized at approximately 94% (NTIA 2000). However, there are significant disparities in telephone penetration between socioeconomic groups. For example, only 78.7% of households with incomes less than $5,000 have telephones, whereas 98.9% of the households with incomes over $75,000 have telephones (NTIA 2000). From a geographic perspective, there is relatively little disparity in telephone penetration *by region* in the United States. The Northeast, Midwest, South, and West all have penetration rates above 92%. However, there is significant variation in telephone penetrations *within regions*. For example, the state of New Mexico (grouped with Southern states in this study) has telephone penetration significantly below 90% (NTIA 2000).

The state of Ohio also exhibits a fair amount of variation where telephone penetration is concerned. Figure 1 illustrates the percentage of non-telephone households in each local exchange.[1] The most significant pockets of households with no phones are found in southeastern Ohio, roughly corresponding to Ohio's Appalachian counties (outlined). Relative to other locations in the

[1] Local exchange polygons correspond to the geographic extent of a telephone exchange(s) service area.

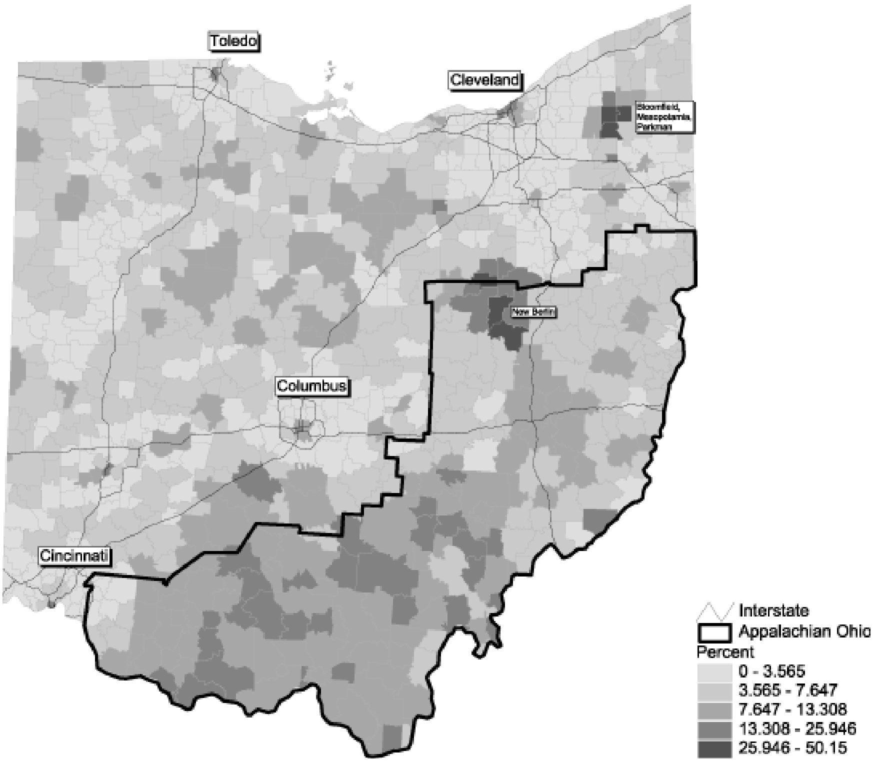

Fig. 1. Households with no phones

state, this is a rural, economically challenged region. However, there are additional pockets of low telephone penetration outside of Ohio's Appalachia, most notably in northeast Ohio. For example, the communities of New Berlin, Bloomfield, Mesopotamia, and Parkman, Ohio display very low penetration rates. In fact, these areas also correspond to Amish Mennonite settlements. The community of New Berlin displays the highest rate of non-telephone households at 50.15%.

Although telephone penetration rates are good indicators of infrastructure availability and its subsequent use, telecommunication services are evolving. The NTIA (2000) survey questions regarding the Internet exemplify the breadth of telecommunication service now considered since the passage of the TA96. The Telecommunications Act of 1996 specifies that universal service be no longer confined to the traditional telephone service. The language in the TA96 elucidates that universal service obligations must include the evolving level of telecommunications services and the definition must take into account new advances in telecommunications and information technology (Mueller 1997).

3. Market demand and xDSL service

As illustrated in the previous section, telecommunication infrastructure is distributed rather unevenly between rural and urban areas for a variety of reasons. First, the historical legacy of the telecommunication system is that of a natural monopoly. Although universal service was an admirable goal, the only way for AT&T to serve rural areas was through a complicated mesh of cross-subsidies. Second, in the current era of deregulation, these cross-subsidies no longer exist. As a result, companies are free to serve the areas they deem most profitable. Initial empirical evidence suggests that urban areas are receiving the majority of telecommunication infrastructure investment (NTIA and RUS 2000). This includes more advanced infrastructure components such as digital switches and points of presence (POPs). This evidence is significant for a number of reasons. As Parker (2000, 284) notes, "... the biggest need for many rural communities is increased broadband capacity on the trunk lines linking their communities to the Internet and to the points of presence of long distance carriers." Without these increases in capacity, it is difficult for companies to offer residential broadband via xDSL or cable because the bandwidth supporting such platforms is simply not available. As a result, the recent NTIA and RUS survey (2000) suggests that broadband services like xDSL are not widely available outside of urban areas. Unfortunately, the problems associated with rural broadband connectivity are more complex than a simple lack of bandwidth in rural communities. Broadband access platforms, specifically digital subscriber lines, require a complex mix of high-quality infrastructure and density of demand (both residential and business demand) that many rural areas are without. The following subsection outlines these infrastructure requirements and explores the technological limitations of digital subscriber line technologies more thoroughly. By providing a more solid understanding of xDSL technologies, a framework for modeling xDSL infrastructure investment and equity and its ramifications on Internet access for rural and urban areas can be explored in Sect. 4.

3.1. Digital subscriber line (xDSL) technology

DSL is a generic name for a family of digital lines being offered by competitive local exchange carriers and incumbent local exchange carriers to their subscribers. Because there are so many varieties, including high-bit-rate (HDSL), very-high-data-rate (VDSL), rate adaptive (RADSL), and symmetric (SDSL), they are often referred to as *xDSL*. Perhaps the most common variety of digital subscriber line technology available to residential customers is the *asymmetric* version, known as ADSL. ADSL uses existing copper wires from the telephone company central office to overlay a high-capacity data channel on top of the existing analog voice channel. However, because the transfer technology is asymmetric, downstream speeds (downloading and web-surfing) are higher than upstream (sending email and attachments) speeds. For example, a typical residential ADSL line might have 640k download and 200k upload speeds.

Although the use of existing copper infrastructure for digital data transmission is promising, current xDSL technologies are limited in utility due to a variety of geographic constraints and infrastructure requirements. As mentioned previously, xDSL service relies on the existing copper infrastructure installed by telephone companies. Perhaps the most important components in the local loop are the wire-centers and central switching offices (CO). "(w)ire-centers are the physical structures where the telephone company terminates

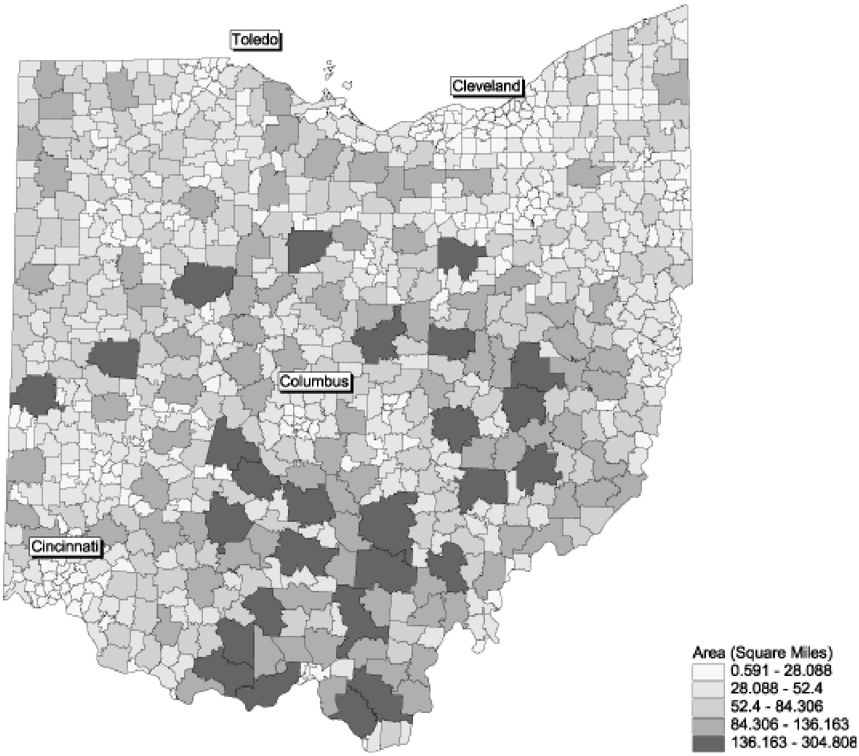

Fig. 2. Wire-center service areas

subscriber outside cable plant (i.e. their local lines) with the necessary testing facilities to maintain them" (Newton 2000). In other words, these wire-centers and central offices serve as hubs for the local exchange, containing the circuit switching equipment for all telephone lines within a geographic area. This geographic area is commonly referred to as a "wire-center service area". Figure 2 illustrates the wire-center service areas for the entire state of Ohio. It is interesting to note that the geographic extent of wire-center service areas varies quite dramatically. In fact, there is a significant (yet moderate) negative correlation (−0.322) between wire-center service area size and population density.[2] This suggests that as local population increases, wire-center size decreases. In other words, telecommunication facilities in rural locations (lower population densities) typically serve larger geographic regions than those found in urban areas. As Egan (1996, 18) notes, "the average loop length for Rural Utility Service telephone companies is 20,330 feet, which is significant considering that access lines longer than 18,000 feet usually require special treatment to ensure high quality basic service." This is an important observation for two reasons. First, this is more evidence suggesting the overall quality and density of telecommunication infrastructure is relatively lower in rural areas than urban areas (Parker 2000; Strover 2001). Second, there are

[2] Pearson's correlation coefficient; Significant at the 0.01 level.

additional aspects of xDSL service limiting the geographic extent of its reach, including the presence of load coils, bridge taps, digital loop carriers, wiring quality and loop length.[3]

From a practical standpoint, the wire-center service area is the "market area" corresponding to each central office because virtually all telephone lines serving households located in a wire-center service area terminate at the CO. Considering that most xDSL equipment is placed in central offices for operation, each wire-center service area represents the potential xDSL market for providers.[4] Consequently, companies looking to upgrade local infrastructure carefully examine the socioeconomic and demographic characteristics of the households in each wire-center service area to determine if a favorable market exists for broadband service (Grubesic and Murray 2002).

4. Statistical modeling approach

As outlined in the previous section, xDSL availability is contingent on a wide variety factors. Not only is household proximity to a central office is important, but the quality of existing telecommunication infrastructure also plays a role. Additionally, telecommunication providers consider the characteristics of the local market area (wire-center service area) before investing in xDSL upgrades for the local central office. This includes preliminary estimates of potential demand as it relates to socioeconomic and demographic characteristics of the local population. This section explores the provision of xDSL service for rural and urban areas, using empirical evidence gathered for the state of Ohio. A methodology for explaining existing xDSL investment is outlined and application results are discussed.

4.1. Study area

The state of Ohio will be used as a case study for examining the spatial disparities of telecommunication access in a rural-urban framework for the United States. With a total population over 11 million, 27% (3 million) of Ohio's residents live in rural areas. Further, 29 of Ohio's 88 counties are considered "Appalachian Ohio"; an area targeted by federal and state government partnerships seeking to promote economic development, strengthen physical infrastructure, and build local and regional capacity (ARC 2000). In addition to the rural segments of Ohio, many large urban complexes are also found in the state, including; Cleveland, Columbus, Cincinnati, Dayton, and Akron. Therefore, given the socioeconomic and demographic diversity found in Ohio, one might suggest that trends identified in this state are representative of trends likely to exist throughout the United States.

[3] For a more thorough discussion, see Grubesic and Murray (2002).

[4] Recent technological advances in the local loop actually extend the reach of xDSL service. Next generation digital loop carriers utilize a hybrid transmission system (copper and optical fiber) to aggregate xDSL traffic from multiple premises, multiplex it (FDM or DSLAM) and send it back to the CO for eventual transmission to the commercial Internet (Newton 2000). It should be noted, however, this type of local infrastructure is the exception, not the norm.

4.2. Data collection and methodology for evaluating xDSL availability

Central office locations and their associated wire-center service areas are available from a variety of data vendors. One of the most widely available data set on wire-center locations is the Local Exchange Routing Guide (LERG) available from Telcordia Technologies. These data contain information on the *locations* of central offices, the geographic extent of their coverage areas, and general information on CO capabilities for the United States. A challenge in performing research in telecommunication is the relative timeliness of such data sources. As a result, many companies pay for monthly updates of the LERG database. More importantly, due to the competitive nature of telecommunication service provision, obtaining data sources documenting the locations of central offices actually offering xDSL service is difficult. The central office data utilized in this study were acquired from the Ohio Supercomputer Center via the Ecom-Ohio project (Ecom-Ohio 2000). Portions of these data are provided by Cincinnati Bell, a corporate partner in the Ecom-Ohio project. The remaining data were acquired utilizing a "web spider". This web spider iteratively searched a xDSL service clearinghouse on the Internet, in order to ascertain which of the remaining central offices were equipped for xDSL service.[5]

1997 Census estimates are utilized for evaluating the market characteristics for each wire-center service area. More specifically, block group estimates of socioeconomic and demographic characteristics for the state of Ohio are aggregated to the wire-center service areas using Maptitude, a commercial geographic information system (GIS). This database is used for both a cartographic and statistical analysis of xDSL availability. In addition, several proxy variables are incorporated into the database as measures of location and competition. One proxy accounts for the degree to which a wire-center service area is urban or rural. In this case, all wire-center service areas within a county classified as part of an Ohio metropolitan statistical area are considered urban. A second proxy variable incorporated into this analysis is that of market competition from cable broadband providers. If a local cable franchise offers broadband Internet service in a community, this is considered a competitive threat to xDSL providers. It is hypothesized that well entrenched cable providers will maintain a dominant market share. This is partially attributable to the ease of cable broadband deployment in the last-mile relative to the initial technical challenges associated with xDSL installation and its geographical service limitations.[6] More importantly, cable broadband currently enjoys a fair level of market momentum, with estimated availability in 60% of American households versus 45% for xDSL (Yankee Group 2001). In fact, the first broadband platform available in Ohio was Time-Warner Roadrunner service (cable), first offered in September of 1996 – long before any xDSL service in the state (OCTA 2002). Therefore, market entry for xDSL providers in a "cable ready" region becomes difficult, or at the very least, less

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[5] The quality of web-spidered data acquired from the Internet and utilized in this study is very good. In fact, these data were crosschecked with matching records provided by Cincinnati Bell for the Ecom-Ohio study. In all cases, the web-spidered data and Cincinnati Bell's locational information matched.

[6] For a more thorough discussion on the technical aspects of xDSL installation and service, see Grubesic and Murray (2002).

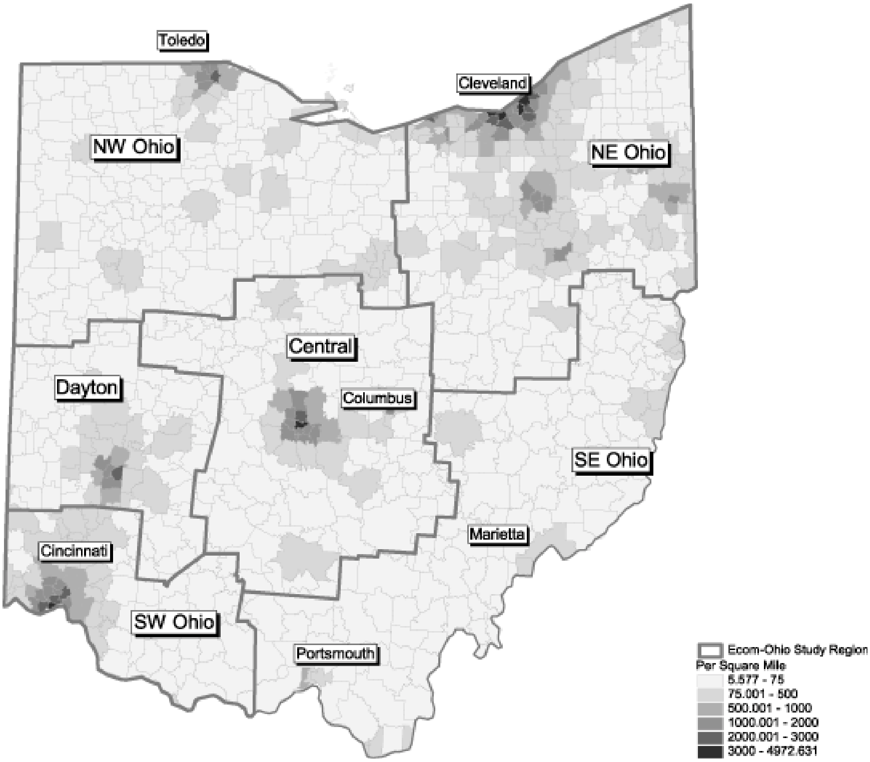

Fig. 3. Household density by wire-center

profitable. As such, all wire-center service areas with cable broadband options are accounted for with the cable competition proxy.

4.3. Cartographic analysis of market indicators

As history indicates, telecommunication providers obtain higher returns on their infrastructure investments in markets dense with customers (Strover 2001; Caristi 2000). Figure 3 illustrates household densities for each wire-center service area in the state of Ohio. To facilitate discussion, the state of Ohio is also subdivided into the six regions (northeast, northwest, southeast, southwest, central, and west-central) illustrated in Fig. 3. Results displayed in Fig. 3 indicate the presence of higher household densities in major urban centers. Also illustrated is the lack of a major urban center in southeast Ohio.

It is important to note that the argument for density as it relates to telephone service is *not* directly comparable with density as it relates to broadband xDSL service. Although high household densities are positive characteristics for potential broadband markets, the households must also contain people interested in using high-speed Internet connections. In many cases, geodemographic and psychographic profiles are frequently used by consulting firms for estimating the likelihood of xDSL adoption at the household level

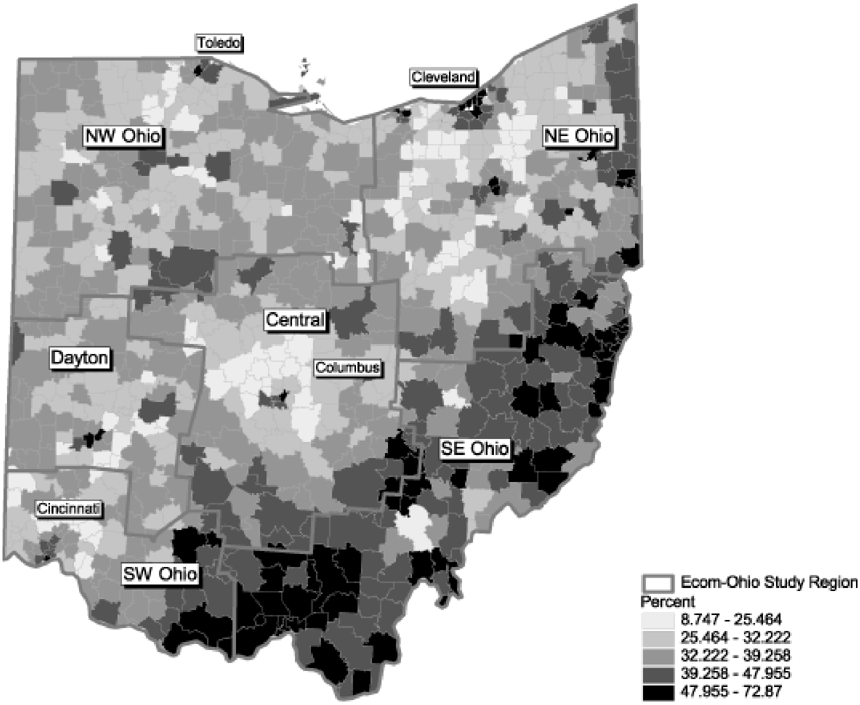

Fig. 4. Households collecting public assistance by wire-center

(Buxton Company 2001). Thus, xDSL providers are in search of wire-center service areas with dense populations of well-educated, economically prosperous residents (the target population for xDSL service) (Grubesic and Murray 2002). In fact, the literature on Internet use suggests households displaying higher levels of both income and education are more apt to use the Internet (Hoffman and Novak 1999; NTIA 1999, 2000). In addition, because xDSL is a premium service with installation charges approaching $300 and monthly service fees ranging between $50 and $200, only a limited number of households can afford such service.[7]

One measure of socioeconomic status is displayed in Fig. 4; the percentage of households collecting public assistance in each wire-center service area. There are two patterns worth noting in this figure. First, many of the wire-center service areas located in major metropolitan regions display high percentages of households on public assistance. This trend is indicative of distressed inner-city neighborhoods, common throughout the major urban centers in Ohio. One might hypothesize that these areas will not attract significant xDSL infrastructure investment. However, due to an increasing

[7] Installation and service fees can vary quite dramatically. Some companies offer a complete rebate on hardware and installation fees. Others still charge fees to account for the overhead associated with co-location. Many believe the RBOCs engage in predatory pricing as a means to eliminate competition (Kushnick 2001; NewNetworks 2001). Therefore, CLECs are frequently unable to offer competitive prices and installation rebates similar to the RBOCs.

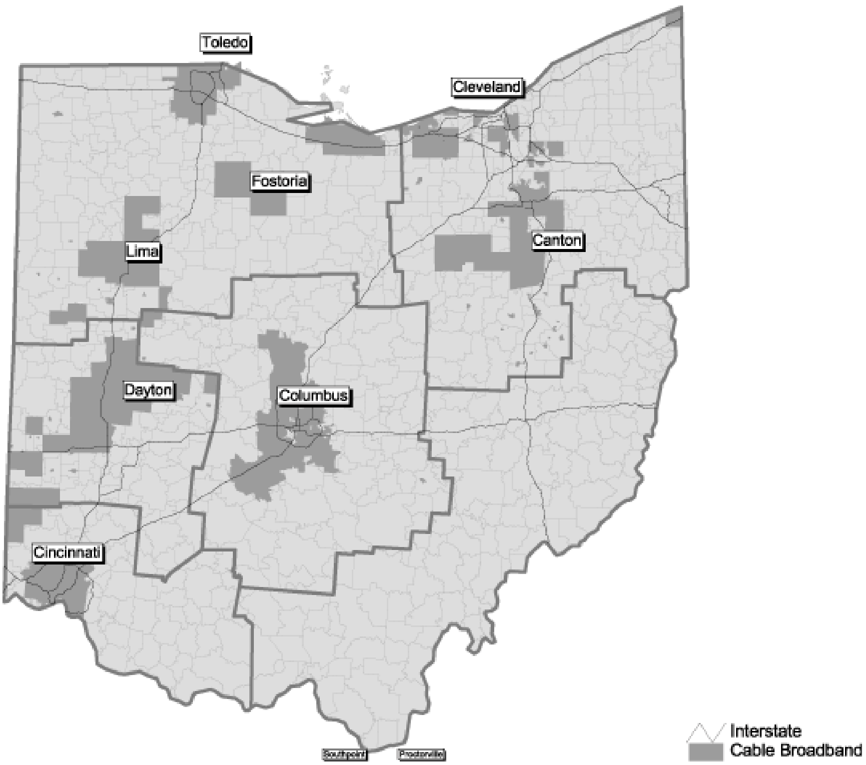

Fig. 5. Cable broadband availability

interest in affordable broadband access for small to medium sized businesses, one might suggest that inner-city neighborhoods (proximal to the CBD) represent a good market opportunity for xDSL providers. Second, southeastern Ohio displays remarkably high rates of households collecting public assistance, indicative of the depressed socioeconomic conditions in the southeast region. Again, it is hypothesized that southeast Ohio is not likely to be an attractive region for xDSL investment due such high rates of socioeconomic distress and its relative isolation from the more populated Interstate 71 corridor.

Given the spatial variation of basic market indicators illustrated in Figs. 3 and 4, it is sensible to explore the spatial patterns of residential broadband provision for the state of Ohio to determine if these patterns visually correlate. Figure 5 illustrates locations where cable broadband services are available. It is clear that of the major metropolitan areas in the state have access to cable broadband. Although cable broadband access is clearly skewed toward the major urban complexes in Ohio, it is not exclusive to these areas. A variety of smaller communities located in northeast and southeast Ohio also have access. This is significant because it suggests that some degree of advanced telecommunication service diffusion is taking place in select, rural market areas.

Figure 6 illustrates xDSL capable central offices and their associated wire-center service areas and also displays the percentage of non-telephone households by wire-center service area. As Fig. 6 illustrates, xDSL providers have

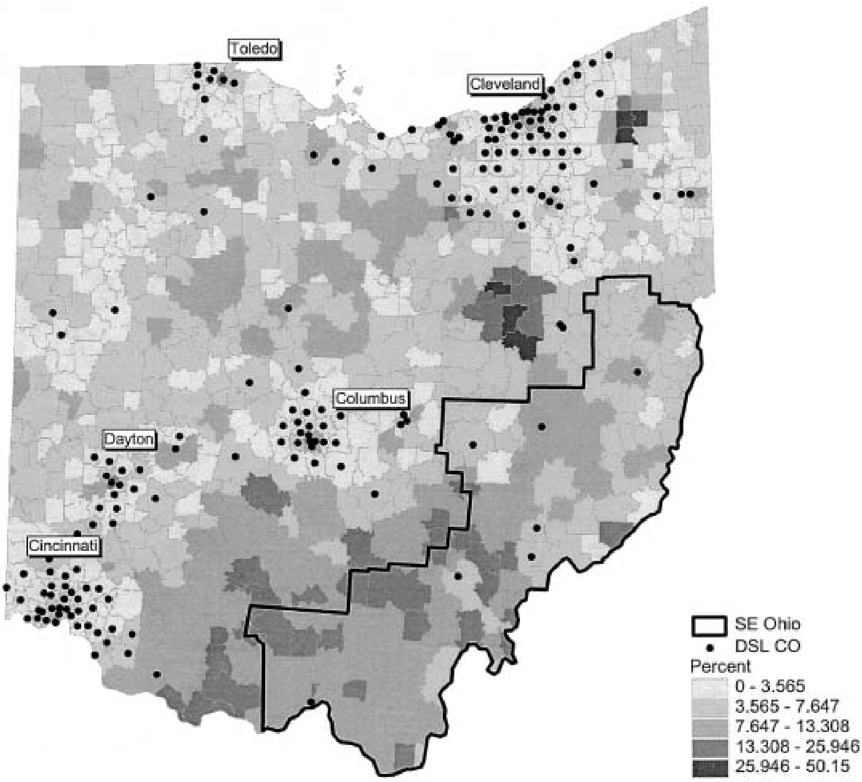

Fig. 6. xDSL enabled COs and non telephone households

targeted major metropolitan areas for service. In fact, the majority of wire-center service areas in Cleveland, Columbus, Cincinnati, Toledo, and Dayton are xDSL enabled. Figure 6 also demonstrates a relatively low occurrence of xDSL enabled COs in service areas with a high percentage of non-telephone households. The southeast region of Ohio best illustrates this; only 6.4% of the wire-center service areas in southeast Ohio are xDSL enabled. However, the presence of several xDSL enabled wire-centers does suggest that select rural areas are not completely without advanced services such as xDSL.

Given the empirical evidence presented in this section, it is clear that the major urban areas in Ohio have a variety of choices for broadband Internet access. These results suggest that both cable and xDSL broadband options are widely available in the cities of Cleveland, Columbus, Cincinnati, Toledo, Dayton, and Akron. However, results indicate that a variety of smaller, rural communities scattered throughout the state also have broadband access options. This apparent diffusion of broadband access to more rural areas merits more extensive analysis. What are the forces driving xDSL availability in more rural locations? Does cable broadband availability attract or deter xDSL infrastructure upgrades? The following section details a statistical methodology for estimating the relationship between socioeconomic and demographic indicators of market demand, location, and the availability of xDSL service.

4.4. Logistic regression analysis

Utilizing a binary dependent variable, three logistic regression models were constructed to explain the market conditions indicative of residential xDSL service availability.[8] For estimation purposes, xDSL availability is binary (wire-centers are either equipped or not) and a function of demographic and economic variables, location, and competition. More specifically, the logistic regression models are used as a means of testing the probability of a wire-center service area gaining xDSL service, or remaining without service, given a set of market conditions. For the purposes of analysis, variables with *p*-values less than 0.05 are considered significant contributors to a wire-center service area's xDSL status. The independent variables included in the regression analyses were not randomly selected. As illustrated in Sects. 4.2 and 4.3, xDSL service appears to have a variety of interesting relationships between indicators of socioeconomic status, location and competition. Table 1 describes the variables used as market indicators for the regression models and outlines their relative values in hypothesis testing.[9]

4.4.1. Model 1

The first logistic regression model explores the relationship between xDSL service and the hypothesized "core" market indicators of household density, educational attainment, and income. Two additional measures of location and competition are also included in this model. First, the URBAREA variable serves as a proxy for location and a relative measure of urban versus rural. Second, the cable competition variable is also included in Model 1.

As illustrated in Table 2, Model 1 displays a significant level of predictive ability. In fact, the Model 1 accurately predicts xDSL service/non-service in 88.7% of Ohio's wire-centers. Factors contributing to xDSL enabled COs in the state of Ohio include higher household densities, higher educational attainment rates (bachelors or graduate degree), and higher median income levels. The rural-urban proxy is also a significant, positive factor in the model. This model suggests that xDSL providers are targeting affluent urban markets for service provision. The cable competition variable was not found to be statistically significant in this model.

4.4.2. Model 2

The second regression model is a small deviation from the first. The core market indicators remain independent variables, however, a slight modification was made to the proxy variable for location. Instead of simply denoting wire-centers within an urbanized area as urban, the URBAREA2 variable

[8] The distinction between *residential* and *commercial* broadband service provision is made here because rather than attempting to determine the market characteristics of commercial xDSL service provision, this paper seeks to explain the presence of xDSL service as motivated by non-corporate entities (households). It is likely that the forces driving commercial and residential demand for xDSL broadband services are significantly different. These differences will be examined in future research.

[9] All variables were screened using a scatterplot procedure to ensure that collinearity was not a problem in the analysis. Variance inflation factors were also calculated.

Table 1. Variables used for logistic regression models

Variable	Status	Definition	Description
Active	Dependent	xDSL broadband availability by wire-center service area 0 = No Service; 1 = Service	Measure of broadband xDSL availability
HH97	Independent	Household density per square mile in wire-center service area	Tests the effect of market density on xDSL service provision
BachGrad	Independent	Percentage of population with bachelors or graduate degree	Tests xDSL availability relative to aggregate educational attainment
MedInc	Independent	Median income	Tests xDSL availability relative to different income levels
RetInc	Independent	Percentage of population collecting retirement income	Proxy variable for age demographic
Urbarea*	Independent	Wire-center Inside urbanized area of a central city (urban) = 1; Wire-center outside urbanized area of a central city (rural) = 0	Proxy variable for location (urban v. rural)
Urbarea2*	Independent	Wire-center inside or adjacent to an urbanized area of a central city (urban) = 1; Wire-center not inside or adjacent to an urbanized area of a central city (rural) = 0	Proxy variable for location (urban v. rural)
MSA**	Independent	Wire-center inside MSA county (urban) = 1; Wire-center outside MSA county (rural) = 0	Proxy variable for location (urban v. rural)
Ccomp	Independent	Inside wire-center = 1; No competition = 0	Tests the effect of cable broadband competition on xDSL service deployment

* An "urbanized area comprises one or more places ("central place") and the adjacent densely settled surrounding territory ("urban fringe") that together have a minimum of 50,000 persons. The urban fringe generall consists of contiguous territory of at least 1,000 persons per square mile (Census Bureau, 2002). For more information, see http://www.census.gov/population/censusdata/urdef.txt

** The general concept of a metropolitan statistical area is that of a large population nucleus, together with adjacent communities, having a high level of social and economic integration with that core. Metropolitan areas comprise one or more complete counties. For more information, see http://www.census.gov/population/www/estimates/aboutmetro.html

includes all wire-centers, both within and adjacent to the urbanized area, as urban. Although the predictive ability of this model remains unchanged at 87.0%, the relative importance of location in Model 2 increases significantly from Model 1 (Wald = 10.327 and 4.688 respectively) (see Table 2). This suggests that xDSL investment is partially contingent on location, with many suburban areas in Ohio attracting xDSL infrastructure investment.

4.4.3. Model 3

The third and final model in this study utilizes a new combination of variables. Although the core market indicators remain important components of

Table 2. Logistic regression results

Variable	Model 1			Model 2			Model 3		
	Coefficient	Wald	Significance	Coefficient	Wald	Significance	Coefficient	Wald	Significance
Constant	−5.102	63.055	0.000	−4.773	54.584	0.000	−4.055	20.767	0.000
HH97	0.000	12.865	0.000	0.000	11.199	0.001	0.000	16.048	0.000
BachGrad	0.000	3.494	0.032	0.000	4.233	0.040	0.000	3.433	0.040
MedInc	0.000	10.023	0.002	0.000	4.382	0.036	0.000	6.456	0.011
Ccomp	0.327	1.569	0.210	0.290	1.240	0.266	–	–	–
RetInc	–	–	–	–	–	–	−0.072	4.058	0.044
Urbarea	0.663	4.688	0.030	–	–	–	–	–	–
Urbarea2	–	–	–	0.934	10.327	0.001	–	–	–
MSA	–	–	–	–	–	–	1.005	10.427	0.001
Final – 2 Log likelihood		473.055			467.410			466.818	
Model chi-square [df]		419.372 [5]			425.017 [5]			425.069 [5]	
Hosmer/lemeshow chi-square [sig]		15.741 [.046]			7.248 [.510]			10.362 [.241]	
% Correct predictions		88.700			88.700			89.400	
Nagelkerke – R^2		0.596			0.602			0.603	

Model 3, a new variable, MSA, serves as the proxy for location. Because MSA counties have relatively high levels of interaction with their central city, as well as strong social and economic similarity, it is hypothesized that the wire-centers in MSAs will also display similar characteristics. That is, wire-centers in MSA counties adjacent to xDSL-equipped wire-centers in central cities will also have the appropriate infrastructure. In addition, the percentage of people collecting retirement income in each wire-center service area is included in Model 3. It is hypothesized that service areas with higher percentages of retirees are less appealing to xDSL providers than service areas with a younger demographic profile. A final modification is the removal of the extraneous cable competition variable as it was determined to be insignificant in Models 1 and 2.

The results of Model 3 indicate a slight increase in predictive capability (89.43%) when compared to Models 1 and 2 (88.7%). Household densities, educational attainment, income, and urban location remain important factors in predicting xDSL service. In addition, Model 3 determined that the percentage of people collecting retirement income is significant (p-value = −0.0440). As hypothesized, this parameter had a negative impact (coefficient = −0.072) of moderate magnitude (Wald = 4.0583) on the dependent variable.

4.5. Model interpretation and empirical results

Although each model displayed a relatively high level of predictive ability, more than 10% of the cases in each model were not properly accounted for. In other words, given the utilized set of independent variables, the models incorrectly estimated the presence of xDSL service in several market areas. A standard method to test the reliability and validity of a regression model is through the examination of residuals. Residual analysis is important in this context because it provides additional insight into the processes contributing to xDSL deployment by highlighting areas where the model performed poorly. A particularly effective procedure is to map residual values to examine any spatial trends in model estimates.

Because Model 3 provided the best estimates of xDSL service availability for the state of Ohio, its residual values are linked to each wire-center service area in an effort to display any spatial trends or biases in the final results (Fig. 7). There are numerous interesting residual patterns evident in Fig. 7. For example, several groups of wire-center service areas are present where Model 3 significantly underestimates the probability of xDSL service availability. Interestingly, several of these groups are located on the outskirts of Cleveland, Columbus, and Cincinnati. Table 3 displays the model results on a select, case-by-case basis for both overestimates and underestimates.

4.5.1. Underestimates

One of the more striking residual patterns evident from Model 3 is the large group of underestimated market areas southwest of Cleveland. Underestimates refer to a positive residual between the actual and predicted values. In

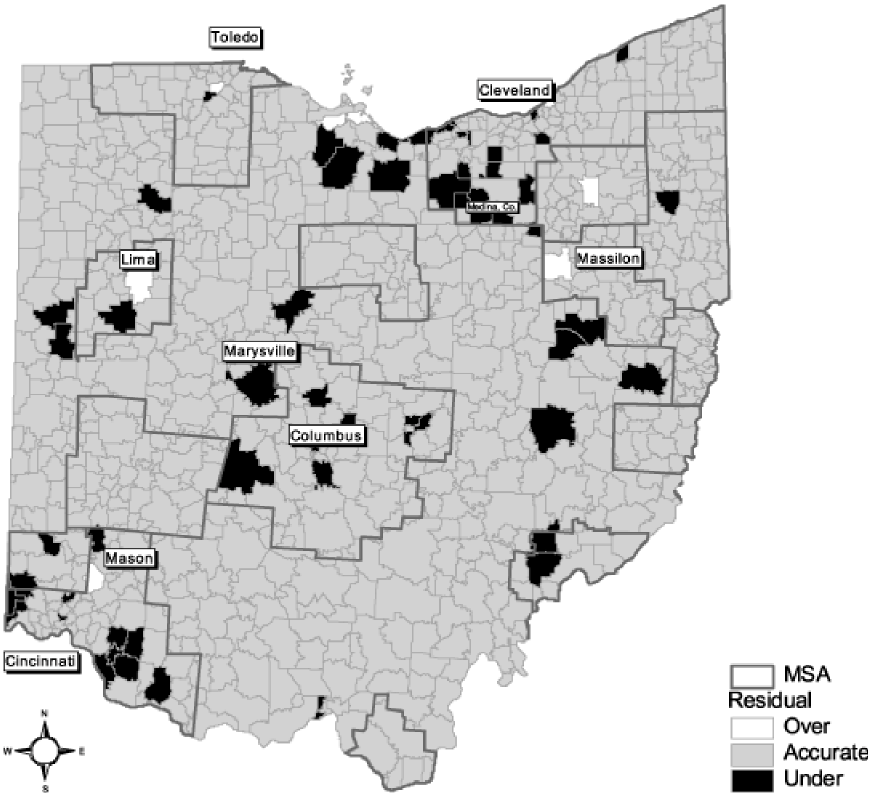

Fig. 7. Residual esimates – model 3

this framework, positive residuals indicate that Model 3 estimated no xDSL service availability for these areas, when xDSL service was actually available. From a geographic perspective, the area southwest of Cleveland (Medina County) is one of the more interesting locations in Ohio. Medina County shares borders with both Summit (Akron) and Cuyahoga (Cleveland) Counties, two of the largest population centers in the state but is a member of the Cleveland MSA. Given this intermediate location, Medina County is currently experiencing a period of significant suburbanization and population growth. In fact, with easy access into downtown Cleveland via Interstate 71 and similar access into downtown Akron via Interstate 76, much of the residential development in Medina County is located in the bedroom communities of Brunswick, Wadsworth, Sharon Center, and Seville, Ohio. As a result, Model 3 underestimates in 60% of the xDSL market areas in Medina County. This trend of underestimation suggests that the 1997 census estimates utilized in the regression models are not reflecting recent suburban and exurban growth. As a result, Model 3 is not able to pick up the increases in household density or rising socioeconomic status in these bedroom communities.

Figure 7 also illustrates several groups of underestimated service areas located in the Cincinnati area (southwest Ohio). With service areas in Ohio, Indiana, and Kentucky, Cincinnati Bell was one of the first telecommunica-

Table 3. Model 3 summary

Underestimates	DSL Yes/No	HH97	BachGrad**	MedInc	MSA	RetInc**	Predicted	Zresidual*
Akron/Cleveland area (Medina)								
Spencer	Y	23.82	5.57	47,145	1	19.262	0.07057	3.62917
Chatham	Y	28.34	6.47	56,980	1	15.533	0.14143	2.72231
Lodi	Y	70.09	8.2	45,207	1	14.933	0.13876	2.63421
Seville	Y	75.95	8.78	47,591	1	14.09	0.16327	2.42636
Sharon Center	Y	49.76	16.89	61,851	1	14.76	0.23262	1.94439
Columbus area								
New Albany	Y	73.47	19.22	59,804	1	18.94	0.20151	1.79098
Lockbourne/Groveport	Y	189.51	6.6	38,921	1	20.41	0.33929	1.31366
Cleveland area								
Independence	Y	379.07	14.67	53,517	1	29.83	0.26172	1.42219
Cincinnati area								
Shandon	Y	69.01	8.85	50,373	1	14.06	0.23115	1.97415
Harrison	Y	162.78	8.86	46,232	1	14.21	0.2686	1.82668
Cleves	Y	96.55	7.85	37,639	1	14.9	0.09877	3.26723
Clermont county								
Batavia	Y	108.12	8.067	42,184	1	12.64	0.20851	2.02041
Williamsburg	Y	47.98	4.2	37,143	1	19.66	0.07116	3.77417
Amelia	Y	142.69	5.33	36,889	1	14.74	0.10535	3.04552
New Richmond	Y	76.45	7.54	42,997	1	17.04	0.13541	2.67282
Bethel	Y	74.38	5.87	39,709	1	17.78	0.13864	2.70048
Overestimates								
Lima	N	242.73	7.15	32,365	1	18.83	0.93008	−3.8337
Massillon	N	314.18	9.39	35,476	1	20.655	0.96266	−5.08054
Mason	N	277.81	21.74	60,437	1	13.13	0.90847	−2.68991

* Standardized residual; ** Values in percent

tion companies in the country to provide xDSL service. In fact, Cincinnati Bell has anointed Cincinnati and its suburbs as "showcase" communities for its DSL services (Ecom-Ohio 2000). As a result, 7% of the businesses in southwest Ohio use DSL service. Moreover, this 7% penetration rate is much higher than any other region in the state and above the national average (Ecom-Ohio 2000). Although Model 3 does an adequate job of predicting xDSL availability for the majority of Cincinnati's central city, the less dense, more suburban locations in Clermont County and western Hamilton County proved more difficult to predict. In effect, Model 3 was not able to account for the aggressive nature of Cincinnati Bell and their xDSL service agenda in these more suburban or rural areas.

4.5.2. Overestimates

In contrast to the underestimates outlined above, there are also areas where Model 3 overestimated the probability of xDSL service. In this case, negative residuals indicate that Model 3 estimated the presence of xDSL service for a market area when it was actually not available. Although the overestimates were fewer in number, there are several cases of worth noting. Lima, Ohio, located in the northwest region, is a small city with a population of approximately 42,000. With a residual value of −3.83, Model 3 did not accurately predict Lima's xDSL status. In reality, Lima is a relatively depressed urban center. With unemployment rates above the state and national averages, demand for high-speed Internet service in Lima is probably lower than one might expect. However, empirical evidence indicates that Time-Warner provides their cable-modem service "RoadRunner" to Lima and several surrounding communities. Given the aggressive nature of Time-Warner's cable operations across the state of Ohio, especially in Columbus and Dayton, one might suggest their presence in Lima is a major factor contributing to the absence of a xDSL enabled CO.

Of additional interest in the Lima, Ohio MSA is the fact that Model 3 under-predicts for Wapakoneta, Ohio. As Fig. 5 illustrates, Time-Warner Dayton does not provide cable broadband service for Auglaize County or Wapakoneta. However, as Fig. 7 illustrates, xDSL services *are* available in the city of Wapakoneta. Interestingly, although an active market for broadband services is present in the Lima MSA, the market's two major centers (Wapakoneta and Lima) are accessing broadband through different platforms. This is an important result, because it suggests that market penetration by xDSL providers has the *potential* to be influenced by the presence (or absence) of an entrenched cable broadband provider.

Additional supporting evidence regarding the benefits of local entrenchment can be found in Massillon, Ohio. With a population of nearly 31,000 and a location in the Canton MSA, one might expect Massillon to have xDSL service available. However, similar to Lima, a very aggressive local cable provider serves the city of Massillon with broadband access. As a result, Massillon Cable makes market penetration for xDSL providers very difficult because they are so well entrenched in the market. With over 4,000 broadband subscribers and 1,100 miles of infrastructure, Massillon Cable serves a substantial market area (Ecom-Ohio 2000).

Another community that Model 3 over-predicted is Mason, Ohio. One would expect this growing city of 20,000, which is adjacent to Cincinnati, to have xDSL services available. Interestingly, Mason's central office is owned and operated by United Telephone Company of Ohio, not Cincinnati Bell. United Telephone of Ohio is a local subsidiary of Sprint and has a major presence across the state of Ohio where it owns and operates 20% of the COs. 100% of United Telephone central offices are *without* xDSL service. At the very least, these results alert one to the uneven nature of infrastructure upgrades by telephone companies across the state, even in relatively urban areas. It also reinforces the fact that Cincinnati Bell is a very aggressive xDSL provider when compared to other regional bell operating carriers in Ohio.

5. Discussion

As hypothesized, household density, income, education, and location play an important role in spurring the provision of residential xDSL service. Model 3 also indicates that wire-center service areas with an older demographic profile are less likely to obtain xDSL service than those with a younger populace. Therefore, although Model 3 does a very good job of predicting residential xDSL broadband service, it is clear there are trends prevalent in several communities that the Model 3 is not accounting for. For example, Model 3 does not account for any factors that might contribute to upgrades in CO infrastructure (xDSL) for the purpose of serving commercial entities. Although evidence suggests that many mid to large-sized corporations utilize direct fiber-optic connections for Internet access (O'Kelly and Grubesic 2002), Grubesic and Murray (2002) suggest that smaller business operations might be interested in xDSL service. In other words, Model 3 does not to incorporate proxies for market demand stemming from the commercial side of broadband service provision as it is beyond the scope of this paper.[10] As a result, the model expected a low probability of xDSL active central offices, when in fact, several high intensity commercial wire-centers located in the Cleveland and Columbus areas have xDSL equipped COs.

Another interesting result is the impact of competition on xDSL service provision. Although a cable competition variable was utilized in Models 1 and 2, it was determined to be statistically insignificant. However, as the analysis of residuals for Model 3 confirms, competition from cable providers has the potential to influence on the market locations where xDSL providers decide to upgrade infrastructure. As illustrated in the previous discussion, both Massillon and Lima are good examples of communities where a cable provider has acquired a dominant market share in the provision of residential broadband services. This type of entrenchment by cable providers can certainly limit the

[10] Because the unit of analysis for this paper is the wire-center service area (larger than a block group or census tract but smaller than a zip code) it is difficult to collect the most current Economic Census (1997) information – which is aggregated to zip codes, counties, or metropolitan areas. For more information on the Economic Census, see http://www.census.gov/epcd/www/econ97.html

appeal of entering a market for xDSL providers. Therefore, one might suggest that the varieties of broadband platforms available in a city are somewhat related to the size of a city. In the case of xDSL and cable, both platforms are widely available in Ohio's major urban centers. However, smaller urban centers such as Massillon and Lima appear prone to market dominance by a particular platform, in this case, cable. However, contrasting both Massillon and Lima is the city of Cincinnati, where several broadband platforms are available. In addition to Cincinnati Bell xDSL services, Time-Warner Communications has made RoadRunner cable broadband available to most of Cincinnati and several suburbs. However, empirical evidence indicates Cincinnati Bell's xDSL service completely dominates the outlying communities of Cincinnati and southwest Ohio, particularly Clermont County and the western portions of Hamilton County. In this sense, one might suggest that Cincinnati Bell is very similar to the cable providers found Massillon and Lima. It has acquired a dominant share of the broadband market in more rural areas, making these smaller (lower density) communities less appealing to cable broadband providers.

Finally, results suggest that newly developing suburban exurban bedroom communities can attract xDSL infrastructure investment. In its current state, Model 3 does not accurately predict xDSL service availability in many of the communities southwest of Cleveland. However, as mentioned earlier, results suggest that this is simply a function of the currency of socioeconomic data utilized for analysis.[11]

6. Conclusion

This paper has attempted to illustrate the marked disparities in the presence of telecommunication infrastructure between rural and urban areas in the state of Ohio. Empirical evidence suggests that federal policy, specifically the Telecommunications Act of 1996, has a significant impact on the location of infrastructure investments. As such, urban areas such as Cleveland, Columbus, Cincinnati, Dayton, Akron, and Toledo display dominant shares of both cable and xDSL broadband infrastructure. However, as telecommunication companies continue to upgrade local infrastructure (cable or xDSL) the ability to access high-speed connections will improve for many. Moreover, the choices for residential broadband are continually expanding. For example, although this paper stresses the availability of cable and xDSL, wireless broadband is also becoming available in many cities around the United States. All things considered, cable, xDSL and wireless technologies hold much promise for helping close the digital divide in the long term. In their current state, however, these technologies are not widely available in all areas. As mentioned in Sect. 2, the intent of the Telecommunications Act of 1996 was to open the market for competition, insure competitive pricing, and increase quality of service. The results of Sects. 3 and 4 indicate the TA96 is not benefiting all areas equally. In fact, results suggest that rural areas are lagging behind urban centers where telecommunication access is concerned. More-

[11] 1997 estimates are the most current data socioeconomic available at the block group level.

over, much of this inequity in service can be attributed to telecommunication providers ignoring "costly" rural markets and providing service to the most lucrative urban sectors.

Given the passage of the TA96 and its pro-competitive policies, why is this urban-rural divide still a problem? In short, the Baby Bells are still a monopoly, owning and controlling nearly all of the infrastructure (wire) running into customers' homes.[12] As such, the Baby Bells have strongly resisted reform and the pro-competitive provisions of the TA96 because they do not want their facilities used by competitors. In particular, the unbundling of the local loop for competition by the Bells has proceeded more slowly than anticipated. This has a clear and direct impact on the provision of xDSL service. Because broadband competition, particularly digital subscriber lines, is centered on the "last-mile" of infrastructure (central office and local loops), it is absolutely necessary to force compliance from the Bells where the unbundling provisions are concerned. In effect, the Tauzin-Dingell Bill would do the exact opposite by exempting Bells from unbundling broadband investments. This makes the provision of xDSL service from competitive local exchange carriers nearly impossible and effectively eliminates the potential for broadband competition in the local loop. Without this competition, many analysts suggest that broadband infrastructure investments from incumbent local exchange carriers would proceed at a much slower rate and ultimately lead to an increase in broadband prices (Hall and Lehr 2002; NewNetworks 2001). On the other hand, if the Bells did unbundle their broadband investments, providing access to last-mile circuits at fair rates, analysts suggest that both upstream and downstream investments would occur, helping ensure a competitive broadband market (Hall and Lehr 2002).[13] From a spatial-economic perspective, this would certainly help lower prices systemwide, and potentially motivate infrastructure investment in a wider array of markets (both urban and rural).

All things considered, the problem of rural broadband access continues to be of great concern. As the telecommunications industry continues to privatize, merge and consolidate, questions of infrastructure equity will become even more important. Specifically, more substantial policy efforts need to be directed toward rural areas to help facilitate the introduction of advanced telecommunication services. This includes a careful, but fair regulation of the Bells in the broadband marketplace to help motivate the unbundling of existing broadband investments and encourage additional investment in lower density (rural) markets. In the case of Ohio, several interesting projects are currently underway. Access Appalachia is the most comprehensive project to date, attempting to evaluate and catalogue local and regional telecommunication infrastructure in southeast Ohio (Access Appalachia 2001). It is hoped that the evidence generated by the Access Appalachia study will motivate policy makers and businesses to reconsider southeastern Ohio for additional support and help identify the appropriate steps needed to address the emerging digital divide in this rural area.

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[12] Of the 191,760,434 switched access lines in the United States, reporting ILECs control 91% (FCC 2002).

[13] Upstream investments include infrastructure and broadband content. Downstream investments include home networking and equipment.

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