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INFRASTRUCTURE AND THE RURAL–URBAN DIVIDE IN HIGH-SPEED RESIDENTIAL INTERNET ACCESS

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As residential Internet access in the United States shifts toward high-speed connections, a gap has emerged in rural high-speed access relative to urban high-speed access. Potential causes of this high-speed "digital divide" include rural–urban differences in people, place, and infrastructure. In this article, Current Population Survey data from 2000, 2001, and 2003 are combined with novel infrastructure data to determine the relative roles of these factors in the rural–urban divide. Bootstrapped decompositions of logit model results demonstrate that rural–urban differences in income and in network externalities, but not in infrastructure, are the dominant causes of the high-speed gap.

Keywords: *digital divide; rural; high-speed; logit decomposition; Internet*

Rates of adoption of new technologies are often lower in rural areas than urban areas. Differences in people, place, and infrastructure have all been found to contribute to this rural technology "penalty." People in rural places may have characteristics such as lower income or education levels that make them less likely to adopt new technologies (McConnaughy and Lader 1998). In particular, the adoption of information and communication technologies (ICTs) has persistently been characterized by income inequalities (Chakraborty and Bosman 2005). In terms of place-based characteristics, rural areas are almost by definition more remote, which often results in a lag in the adoption of innovations. This slow diffusion from urban centers to more isolated areas has been documented for agricultural goods such as hybrid corn (Griliches 1957) as well as for Internet-related technologies (Townsend 2001; Grubesic and O'Kelly 2002). Alternatively, households in remote rural areas may receive fewer network

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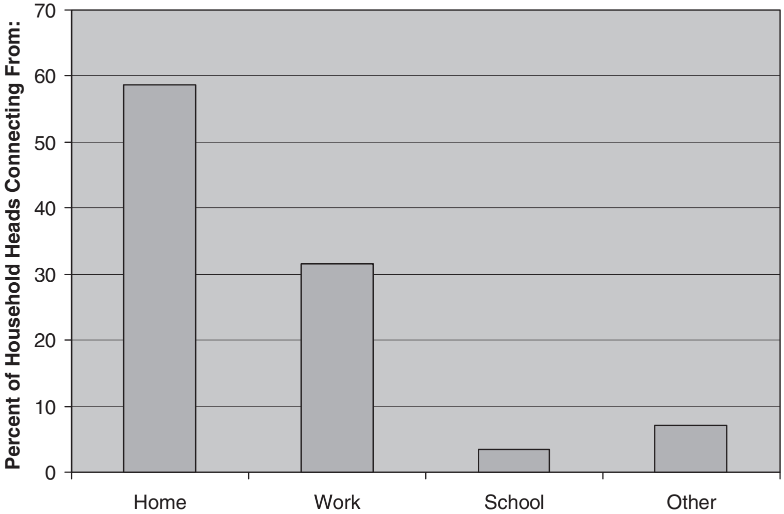

FIGURE 1. Internet Connectivity by Place, 2003

externalities from increased local adoption of technologies (Graham and Aurigi 1997). Fewer people and lower population densities in rural areas may inhibit the public or private provision of high fixed-cost infrastructure to support new technologies (Greenstein and Lizardo 1999; Downes and Greenstein 2002).

The relative importance of people, place, and infrastructure in explaining rural–urban differences in adoption is likely to vary by technology characteristics, as are appropriate policies to address observed disparities. The Internet has, arguably, been the most important new technology to be widely adopted by U.S. households over the last decade and provides an opportunity to examine the relative roles of people, place, and infrastructure in the rural–urban divide in the use of digital communication technologies. In fact, the divide in residential Internet access rates has already been the focus of studies on rural technology gaps and on the potential importance of the Internet for rural economies (Strover 2001; Malecki 2003). Residential connections are an important mode of Internet access. While some individuals may have Internet access at work or school, and most can connect via a communal provider such as a library, access from home is still the dominant form of connection for heads of households (figure 1). Although most students now have somewhat equal access at school, additional access to the Internet to complete assignments is often required at home, where a significant access gap still exists (NTIA 2002). Furthermore, in 2004, the top three reasons for Internet use were sending e-mail, researching products or services, and getting maps or directions (Fellows 2005). Concerns about privacy issues or duration of online sessions are much lower when performing these (and other) tasks from home versus from the office or library. Thus, the personal

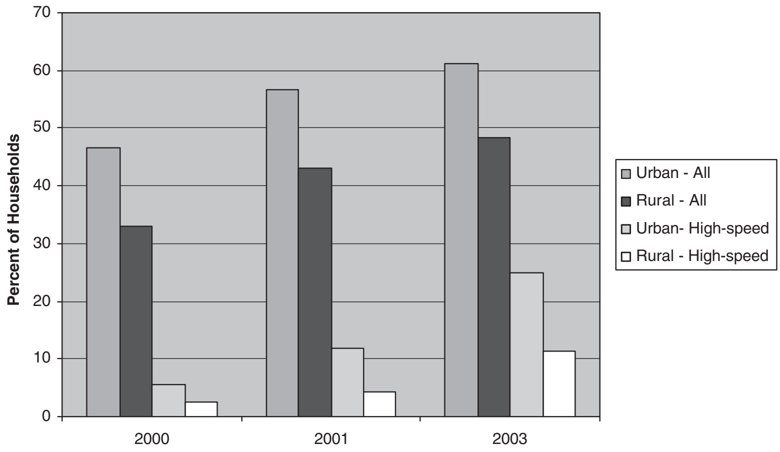

FIGURE 2. Residential Internet Access and the Rural-urban Digital Divide

nature of dominant Internet activities suggests that rural–urban gaps in residential access rates continue to represent a significant digital divide.

In possibly the most complete accounting to date of the role of people and place, Mills and Whitacre (2003) find that differences in household characteristics, particularly lower income and education levels in rural areas, accounted for approximately two-thirds of the rural–urban gap in *general* residential Internet access in 2001. Furthermore, the remaining third of the gap is accounted for by aggregate regional rates in general Internet access. Communications infrastructure is, by inference, not an important factor, but it is not explicitly accounted for in their study.

The minimal role of infrastructure in explaining *general* residential access in 2001 is not surprising given that dial-up access, requiring only a standard telephone line, was the dominant technology at that time. However, after 2001 the share of residential access through high-speed connections, which are increasingly necessary for audio and video Internet applications, increased dramatically (figure 2).[1] Perhaps more importantly, the rural–urban gap in general residential Internet access transformed into a gap in high-speed access. By 2003, the percentage of households with dial-up residential Internet access was actually slightly higher in rural areas (37 percent) than urban areas (36 percent).[2] But the share of households with high-speed access was 11 percent in rural areas compared to 25 percent in urban areas. This gap in high-speed access accounts for the entire observed rural–urban divide in general Internet access in 2003.

There is reason to believe that the factors underlying this emerging gap in high-speed access may be different from those underlying the previous gap in dial-up access, particularly with respect to infrastructure. While telephone service for dial-up access is nearly universally available, important differences in digital communication technology (DCT) infrastructure exist in rural and urban areas. For example, Federal Communications Commission survey data from 2000 indicate that the 70 percent of U.S. ZIP code areas containing households with high-speed Internet connections account for 95 percent of the population (Prieger 2003). The remaining 30 percent of ZIP code areas without any evidence of high-speed residential connections contain only 5 percent of the population. Thus, ZIP code areas without high-speed connections are primarily low-density regions that are rural in nature.

This article examines the roles of people, place, and DCT infrastructure in the rapidly emerging rural–urban divide in high-speed residential Internet access. As part of that effort, novel DCT infrastructure measures are developed for rural and urban areas of the United States. These infrastructure measures are then combined with household attribute data to empirically estimate relationships with household decisions to access the Internet through high-speed connections. The results are used to simulate the contributions of people, place, and infrastructure differences to the rural–urban high-speed digital divide and to evaluate the potential of policies to close the divide.

Data and Descriptive Statistics

Survey data on individual household characteristics and Internet access are obtained from Current Population Survey (CPS) Supplemental Questionnaires on Household Computer and Internet Use in 2000, 2001, and 2003. These are nationally representative surveys of approximately 50,000 households. The major drawback of this data for the current study is that the lowest level of geographic information available on a household is rural or urban status within a state. Residential Internet access is defined by a positive response to the question, "Does anyone in the household connect to the Internet from home?" Additionally, the survey identifies whether the household connects via a dial-up modem or a higher-speed connection.[3] Table 1 displays descriptive statistics for rural and urban area household characteristics that previous research suggests might affect residential Internet access. Rural household heads have, on average, lower education and income levels than their urban counterparts for all years.[4] Additionally, rural areas are less racially diverse, have older household heads, and have a higher incidence of married couples than urban areas. Rural households are also more likely to be headed by a male, have no children present, and have a retired household head. It is also worth noting that rural households are much less likely to have Internet access at work (netatwork) when compared to their urban counterparts.

In terms of place-based characteristics, network externalities (the concept that each network member's utility increases as more members enter the network) may play an important role in determining the magnitude of the benefits associated with residential Internet access. CPS data from 2000, 2001, and 2003 document substantial regional variation in high-speed Internet access rates that

TABLE 1. Household Characteristics by Rural/Urban Status

		Urban			*Rural*		
		2000	*2001*	*2003*	*2000*	*2001*	*2003*
Family Characteristics	Variable Name						
Income							
Under $5K		2.95	2.84	3.06	4.62	4.28	3.98
$5K-$7.5K	faminc1	2.89	2.73	2.77	5.42	5.19	4.89
$7.5K-$10K	faminc2	2.97	2.92	2.92	4.42	4.36	4.11
$10K-$12.5K	faminc3	3.74	3.59	3.53	5.74	6.02	5.49
$12.5K-$15K	faminc4	3.35	3.33	3.13	5.19	5.33	5.33
$15K-$20K	faminc5	5.42	5.19	4.96	8.12	7.50	7.44
$20K-$25K	faminc6	6.95	7.04	6.38	9.56	9.13	8.80
$25K-$30K	faminc7	7.22	6.51	6.64	8.33	8.09	8.64
$30K-$35K	faminc8	6.77	6.28	6.75	7.67	7.43	7.78
$35K-$40K	faminc9	6.34	6.05	6.12	6.66	6.76	6.40
$40K-$50K	faminc10	9.22	9.87	9.54	10.19	9.34	9.04
$50K-$60K	faminc11	9.38	9.21	8.75	7.46	8.42	8.84
$60K-$75K	faminc12	9.55	9.66	9.87	6.94	7.08	8.38
$75K +	faminc13	23.26	24.76	25.58	9.67	11.07	10.87
Education							
No High School		13.33	12.86	12.12	19.90	19.03	17.87
High School	hs	26.60	26.62	26.29	37.20	36.75	36.67
Some College	scoll	27.63	28.35	27.94	25.40	26.88	27.54
Bachelor's Degree	coll	20.73	20.21	21.37	11.38	11.28	11.35
Higher than Bachelor's	collplus	11.73	11.95	12.27	6.12	6.05	6.57

(continued)

TABLE 1. (continued)

		Urban			*Rural*		
		2000	*2001*	*2003*	*2000*	*2001*	*2003*
Race/Ethnicity							
White		82.12	82.12	81.48	89.25	89.53	88.59
Black	black	13.22	13.19	12.40	8.06	7.92	7.70
Other	othrace	4.66	4.69	6.12	2.69	2.55	3.71
Hispanic	hisp	9.78	9.98	11.25	4.56	4.34	5.89
Household Composition							
Married	married	54.25	53.74	53.64	58.04	56.91	57.23
Age of Head	peage	47.06	47.16	47.22	49.81	50.09	50.03
Headed by Male	sex	55.26	53.90	53.71	57.37	55.84	55.12
No Children		68.13	65.46	66.06	70.53	67.06	67.85
1 child	chld1	13.95	14.67	14.29	13.31	13.83	13.24
2 children	chld2	12.76	13.11	13.09	11.21	12.10	12.33
3 children	chld3	3.58	4.90	4.75	3.52	4.91	4.66
4 children	chld4	1.14	1.41	1.46	0.91	1.56	1.30
5+children	chld5	0.44	0.45	0.49	0.52	0.55	0.47
Employed Head	employed	70.29	69.33	68.09	64.50	63.03	61.08
Internet Characteristics							
Home	access	46.67	56.57	61.23	32.90	42.94	48.40
Work	netatwork	22.12	31.91	34.10	11.90	20.23	21.10
High Speed	highspeed	5.47	11.82	25.01	2.48	4.30	11.22
Number of Households		26,413	31,006	29,841	8,601	10,605	10,331

Sources: Current Population Survey Computer and Internet Use Supplements, 2000, 2001, and 2003.
Note: Characteristics without variable names represent the ‘‘default’’ household.

may give rise to regional network externalities. Such externalities have been noted based on several surveys that observe the prevalence of "localized" user communities on the Internet and the promotion of social networks by the Internet (Horrigan 2001; 2006). Furthermore, Sinai and Waldfogel (2004) show that the demographic composition of the population surrounding a household impacts its Internet connectivity rate, while Miniaci and Parisi (2006) document the existence of significant peer impacts on the computer skills of households. Thus, variation in high-speed access rates potentially generates higher network externalities from residential Internet access in some regions than in others. State-level residential rural and urban Internet high-speed access rates (regdensity) are included in appendix A.

The construction of state level rural and urban area measures of the availability of digital technology infrastructure is an important contribution of this article. Since the early 2000s, the two dominant forms of residential DCT infrastructure have been cable Internet and Digital Subscriber Lines (DSL). In fact, these technologies accounted for 99 percent of the residential high-speed market from 2000 until 2004, with satellite and wireless communications making up the other 1 percent (FCC 2004). This study employs measures of DCT infrastructure constructed from two distinct data sources on cable Internet and DSL capacity. Information on county-level cable Internet capacity is documented in the *Television and Cable Factbooks* (2000, 2001, and 2003). Similarly, the Tariff #4 dataset available from the National Exchange Carriers Association (NECA) provides information on the DSL capability of every central office switch in the United States (approximately 38,000 in 2003), along with the city or town served by each central office switch. The 2000, 2001, and 2003 versions of the dataset are used to estimate DSL capacity in those years. A digital technology infrastructure index is then created for every county (or city) by weighting the capability of various technologies in that county (or city) by the population.[5] The index implicitly assumes that all residents of a county/city where infrastructure exists have that infrastructure available to them. To mesh the index with household data from the CPS, it is further aggregated to rural/urban areas within a state. Hence, the ultimate output from these data sources is an estimate of the relative share of the population living in rural and urban areas of each state that have DSL and cable DCT infrastructure (capacity) available to them (appendix B).[6]

A country-level summary of the share of rural and urban population with DSL and cable Internet capacity in their counties is presented in table 2. This table, along with the more detailed data in appendix B, provides some insight into the diffusion of DCT infrastructure over the period 2000 to 2003. The period saw dramatic increases in the percentage of both rural and urban populations with cable and DSL high-speed infrastructure capacity, but rural areas still lag behind urban areas. Furthermore, the percentage point gap is growing for cable Internet capacity. The diffusion of DCT infrastructure has been very different for various regions of the country. Rural and urban regions of several southern

TABLE 2. Percent of U.S. Rural/Urban Population with DCT Infrastructure Capacity

	2000	*2001*	*2003*
Cable			
Rural	4.66	5.47	44.10
Urban	25.08	27.68	75.75
DSL			
Rural	3.43	6.39	29.55
Urban	21.61	32.05	42.39

Sources: Cable Television Factbook, NECA Tariff #4 Data for 2000, 2001, and 2003.
Note: DCT = digital communication technology; DSL = digital subscriber lines.
This table assumes that if the infrastructure exists within a rural or urban county (or city), the population of that county (or city) has infrastructure capacity.

states (particularly Florida, South Carolina, North Carolina, and Arkansas) saw large increases in the availability of DSL between 2001 and 2003, consistent with BellSouth's aggressive deployment of DSL starting in late 2001 (Pinkham Group 2002). Rural areas of other states either continued to have low DSL capacity (mostly mountain states such as Idaho, Wyoming, and Arizona) or saw their rate of capacity growth slow (California, Hawaii). Significant variation also occurred in the diffusion of cable Internet capacity. Rural areas in Arkansas, Ohio, Florida, and New Hampshire saw their cable Internet capacity increase dramatically in 2003, while rural areas of Utah, Colorado, and New York saw very limited increases.

Thus, the exposure of the population to DCT infrastructure has varied not only across rural and urban areas generally, but by region and state as well. The role of this uneven distribution of DCT infrastructure in the high-speed rural–urban digital divide is currently unknown. The next section discusses the empirical model employed to understand the contribution of DCT infrastructure and other factors to the rural–urban digital divide in high-speed residential Internet access.

METHOD

STATISTICAL MODEL

The statistical model for estimating the influence of household characteristics, network externalities, and DCT infrastructure on high-speed Internet adoption is specified as

$$y_i^* = X_i\beta + Z_i\delta + H_i\gamma + D1_i\tau_1 + D2_i\tau_2 + N_i\pi + \varepsilon_i \quad (1)$$
$$y_i = 1 \text{ if } y_i^* \geq 0$$
$$y_i = 0 \text{ if } y_i^* < 0$$

where y_i^* is a latent measure of the benefits from residential high-speed Internet access relative to the costs of household i, y_i is the actual observation of household high-speed Internet access, X_i is a vector of household income levels, Z_i is a vector of household education levels, H_i is a vector of other household characteristics, $D1_i$ and $D2_i$ are the measures of DSL and cable availability discussed in the previous section (dslaccess and cableaccess), N_i is a measure of the regional rate of high-speed Internet access that serves as a proxy for network externalities (regdensity); $\beta, \delta, \gamma, \tau_1, \tau_2, \pi$ are the associated parameter vectors, and ε_i is the statistical model's error term. Because of the discrete nature of the observed Internet adoption decision, a logit model is employed.[7]

Two variables are not included in equation 1 that merit discussion. The first is a cost variable for high-speed access. The access decision may depend on the cost required to obtain the high-speed service. However, CPS data from 2000 shows rural household costs that are slightly below ($26 per month) urban household costs ($31 per month) for high-speed connections.[8] On the other hand, multiple providers do appear to slightly lower costs. Pew survey data from 2004 show that households in areas with only one high-speed provider paid on average $43 per month, compared to $38 per month for those with more than one provider (Horrigan 2006). In either case, the relatively small disparities suggest that cost differences in residential Internet access in rural and urban areas are likely not driving the divide. Furthermore, no cost data is recorded in the 2001 or 2003 CPS surveys used in this analysis. Thus, the inclusion of cost in the empirical model is not possible. Secondly, no measure of market size is included in the model. Market size plays a role in infrastructure investment (Prieger 2003). However, Sinai and Waldfogel (2004) find that the tendency to connect to the Internet is not affected by market size. In the current application, the suppression of geographic detail in the CPS data prevents the inclusion of market size in the empirical model.

Previous research and economic intuition help to identify the expected signs of all model variables. Education and income are both expected to be positively associated to the household high-speed Internet access ($\beta > 0$, $\delta > 0$) (Cooper and Kimmelman 1999). Other household characteristics, as a group, are also expected to influence the access decision ($\gamma \neq 0$) (Bimber 2000; Rose 2003). Higher levels of DSL and cable Internet capacity are both expected to increase the probability of high-speed adoption for a household, as are higher regional access rates ($\tau_1 > 0$, $\tau_2 > 0$, $\pi > 0$) (Prieger 2003; Horrigan 2001).

Decomposition of the Logit Model

A non-linear version of the Oaxaca-Blinder decomposition technique is employed to determine the contribution of each factor to the rural–urban digital divide (Oaxaca 1973; Blinder 1973). The standard (linear) Oaxaca-Blinder decomposition of the general rural–urban digital divide in residential Internet access can be expressed as:

$$\bar{Y}^U - \bar{Y}^R = (\bar{X}^U - \bar{X}^R)\hat{\beta}^U + \bar{X}^R(\hat{\beta}^U - \hat{\beta}^R), \quad (2)$$

where $\bar{Y}^G$ is the average rate of Internet access, $\bar{X}^G$ is a row vector for average values of the independent variables, and $\hat{\beta}^G$ is a vector of coefficient estimates for rural/urban status G. Following Fairlie (2003), the decomposition for a nonlinear equation, such as $Y = F(X\hat{\beta})$, can be written as:

$$\bar{Y}^U - \bar{Y}^R = \left[\sum_{i=1}^{N^U} \frac{F(X_i^U \hat{\beta}^U)}{N^U} - \sum_{i=1}^{N^R} \frac{F(X_i^R \hat{\beta}^U)}{N^R}\right] + \left[\sum_{i=1}^{N^R} \frac{F(X_i^R \hat{\beta}^U)}{N^R} - \sum_{i=1}^{N^R} \frac{F(X_i^R \hat{\beta}^R)}{N^R}\right] \quad (3)$$

where N^G is the sample size for rural/urban status G. Equation 3 applies urban and rural coefficient estimates to the two distinct groups of explanatory variables, X_i^U and X_i^R. Equivalently, the decomposition can be written as:

$$\bar{Y}^U - \bar{Y}^R = \left[\sum_{i=1}^{N^U} \frac{F(X_i^U \hat{\beta}^R)}{N^U} - \sum_{i=1}^{N^R} \frac{F(X_i^R \hat{\beta}^R)}{N^R}\right] + \left[\sum_{i=1}^{N^R} \frac{F(X_i^U \hat{\beta}^U)}{N^U} - \sum_{i=1}^{N^R} \frac{F(X_i^U \hat{\beta}^R)}{N^U}\right] \quad (4)$$

This first bracketed term on the right-hand side of equations 3 and 4 represents the part of the digital divide because of group differences in the distributions of the explanatory variables X. The choice of which set of parameters to use (either $\hat{\beta}^U$ in equation 3 or $\hat{\beta}^R$ in equation 4) is the essence of the familiar "index problem" in the Oaxaca-Blinder decomposition, and can be the source of significantly different results. Some studies suggest using the weighted average parameters ($\hat{\beta}$ instead of $\hat{\beta}^U$ or $\hat{\beta}^R$) from a pooled sample of the two groups (Neumark 1988; Oaxaca and Ransom 1994).

Calculating the contributions from individual explanatory variables included in the first bracketed term of equation 3 or 4 requires "replacing" a single rural characteristic (for example, education level) with its urban counterpart. Hence, a one-to-one mapping of the rural and urban samples is needed to establish an urban counterpart for each rural observation. To create such a mapping, propensities for Internet access are calculated for all observations (both rural and urban) using the specification in equation 1. Since the sample size for urban households is larger than the sample size for rural households, a sub sample of urban households is randomly drawn equal in size to the rural sample. This sampling procedure will clearly affect $\bar{Y}^U$ and X_i^U, since both are dependent on the households included in the sample. However, results from the entire urban sample can be approximated by bootstrapping a large number of urban samples and averaging the results of the decomposition.

The two individual samples (the full rural sample and random urban sub sample) are then ranked by predicted probability of Internet access. Hence, rural households that have characteristics placing them high (low) in their Internet access propensity distribution are matched with urban households that have characteristics placing them high (low) in their own Internet access propensity distribution. To accomplish the decomposition, let X_i, $D1_i$, and N_i be three of the distinct sets of independent variables listed in equation 1: X_i represents income levels, $D1_i$ represents DSL infrastructure capacity, and N_i represents network externalities.[9] Using coefficient estimates $\hat{\beta}$ from a logit regression of a pooled sample of both rural and urban households, the independent contribution of X_i to the digital divide can be expressed as:[10]

$$\frac{1}{N^R}\sum_{i=1}^{N^R} F(\hat{\beta}_0 + X_i^U\hat{\beta}_1 + D1_i^U\hat{\beta}_2 + N_i^U\hat{\beta}_3) - F(\hat{\beta}_0 + X_i^R\hat{\beta}_1 + D1_i^U\hat{\beta}_2 + N_i^U\hat{\beta}_3) \quad (5)$$

Similar expressions can be written for the contributions of $D1_i$ and N_i. Hence, the contribution of each group of variables to the gap equals the change in average predicted probability from replacing the rural distribution with the urban distribution for that group of variables while holding the distributions of the other groups constant.[11] Standard bootstrapping methodology dictates that this procedure should be repeated for a large number of urban sub samples (1,000 samples were used in practice). The average contributions of X_i, $D1_i$, and N_i can then be used to approximate the result for the entire urban sample. This decomposition technique is particularly useful because the sum of the contributions from the individual groups will be equal to the total contribution from all variables in the sample (Fairlie 2003).

It is important to note that equation 5 deals *only* with the first bracketed term of the decomposition shown in equations 3 and 4. The second bracketed term in equations 3 and 4 above represents the portion of the gap because of differences in underlying rural–urban parameters, and is not affected by differences in explanatory variables. The three categories of independent variables discussed above, along with this residual portion, make up the entire rural–urban digital divide in a given year.

RESULTS

The pooled parameter estimates for the household high-speed access decision in 2000, 2001, and 2003 are presented in table 3. Parameter estimates for most of the independent variables have the expected signs. In particular, for all years, the parameter values for education are positive, and increase as the level of education increases. This implies that, relative to a household headed by an individual with no high school education, higher levels of education increase the relative odds of a household having high-speed Internet access. Similarly, the parameter values for income are significantly positive after income reaches $40,000 (faminc10). These parameters increase in value as the income level rises, and jump considerably for the highest level of income (faminc13-$75,000 or more). Hence, having an income level above $75,000 may be particularly important in determining high-speed access. Additionally, the presence of Internet access at work (netatwork) positively impacts the probability of residential

TABLE 3. Logit Model Results for High-speed Access

Dependent Variable: High-speed

	2000			*2001*			*2003*		
Variable	*Coefficient*	*S.E.*		*Coefficient*	*S.E.*		*Coefficient*	*S.E.*	
hs	0.3163	0.1701	*	0.6210	0.1182	***	0.5498	0.0860	***
scoll	0.7519	0.1686	***	0.9818	0.1175	***	0.9864	0.0857	***
coll	0.9178	0.1726	***	1.1229	0.1209	***	1.1951	0.0891	***
collplus	0.8821	0.1793	***	1.0411	0.1260	***	1.2460	0.0934	***
faminc1	−0.7493	0.4632		−0.9969	0.2991	***	−0.3134	0.1702	*
faminc2	−0.5461	0.4506		−0.5521	0.2666	**	−0.4903	0.1748	***
faminc3	−0.3761	0.3810		−0.1605	0.2186		−0.3504	0.1591	**
faminc4	−0.1967	0.3694		−0.3315	0.2310		−0.3615	0.1603	**
faminc5	−0.1790	0.3211		−0.3509	0.2015	*	−0.2799	0.1410	**
faminc6	−0.1249	0.2941		−0.3236	0.1868	*	−0.1266	0.1299	
faminc7	0.3153	0.2852		−0.0909	0.1836		0.0216	0.1256	
faminc8	0.4778	0.2793	*	0.0905	0.1777		0.0434	0.1253	
faminc9	0.2053	0.2888		0.0979	0.1788		0.1034	0.1262	
faminc10	0.5184	0.2750	*	0.2759	0.1683		0.3310	0.1183	***
faminc11	0.6501	0.2787	**	0.3401	0.1690	**	0.4803	0.1188	***
faminc12	0.7301	0.2752	***	0.5921	0.1684	***	0.6228	0.1179	***
faminc13	1.1294	0.2700	***	0.9060	0.1641	***	1.0522	0.1153	***
netatwork	0.2278	0.0670	***	0.2496	0.0449	***	0.2748	0.0356	***
black	−0.4591	0.1212	***	−0.4599	0.0836	***	−0.4371	0.0605	***
othrace	−0.1497	0.1351		0.0861	0.0898		0.0437	0.0697	
hisp	−0.4301	0.1418	***	−0.3498	0.0968	***	−0.3470	0.0652	***
peage	0.0120	0.0140		0.0005	0.0092		0.0156	0.0075	**
age2	−0.0003	0.0002	**	−0.0002	0.0001	**	−0.0004	0.0001	***
sex	0.1757	0.0621	***	0.1653	0.0418	***	0.1589	0.0323	***
married	0.0688	0.0700		0.0810	0.0490	*	0.1593	0.0386	***
chld1	0.0147	0.0947		0.0353	0.0574		0.0781	0.0457	*
chld2	0.0721	0.0949		0.0043	0.0597		0.0683	0.0472	
chld3	−0.0533	0.1499		0.0044	0.0873		−0.0412	0.0721	
chld4	−0.0186	0.2716		0.0353	0.1545		−0.1879	0.1366	
chld5	0.1443	0.1906		−0.0348	0.2800		−0.1940	0.2300	
regdensity	12.3028	1.7871	***	3.8693	0.4967	***	2.6571	0.3019	***
cableaccess	−0.1503	0.1752		−0.2970	0.1102	***	0.1465	0.0913	
dslaccess	0.1101	0.1175		0.1683	0.0734	**	0.1586	0.0579	***
retired	0.0665	0.1514		0.0728	0.1041		0.0255	0.0787	
nm	−0.1646	0.1098		−0.5661	0.0769	***	−0.2717	0.0628	***
constant	−4.7240	0.4317	***	−3.4153	0.2728	***	−3.3133	0.2196	***

Note: ***, **, and * indicate statistical significance at the $p = 0.01$, 0.05, and .10 levels, respectively.

high-speed Internet access, while the presence of a black or Hispanic household head decreases the likelihood of high-speed access in all years.

The parameter estimates for chld1, chld2, or chld3 are not significant in any of the years. Apparently, the presence of children in the household does not play a significant role in the high-speed adoption decision. This result is somewhat surprising as large bandwidth is necessary for many common Internet activities of children under the age of eighteen, such as music downloading and online gaming (Horrigan 2004). Another surprising result is the lack of significance of the linear age term (peage) in 2000 and 2001, and only marginal significance in 2003. However, the quadratic age term (age2) is negative and at least marginally significant in all years, suggesting that the adoption propensity decreases rapidly with the age of the household head. If young families are most likely to have high-speed access, this may in part explain the lack of significance of children. Finally, households headed by a male are more likely to have high-speed access in all years. This result is reminiscent of the "gender divide" documented during the early days of dial-up adoption (Bimber 2000).

Turning now to the impact of place-based variables, rural status of the household has a significant and negative effect on high-speed residential Internet access in the years 2001 and 2003. This implies that even after controlling for differences in household characteristics (such as education and income) between rural and urban households, location in a rural area decreases the probability of high-speed access. Furthermore, the significant positive coefficient on regdensity indicates that regional connectivity rates are important in the high-speed access decision, with higher regional rates resulting in increased probability of access for a household.

From an infrastructure standpoint, DSL capacity parameter estimates are positive and significant in 2001 and 2003, meaning that higher DSL infrastructure capacity was a significant factor in the high-speed adoption decision. Interestingly, the coefficient for cable access is negative in 2001, implying that higher availability of cable Internet *decreased* the probability of high-speed access in this year. Several points are worth making regarding this counterintuitive result. DSL infrastructure clearly has a larger impact than cable on the probability of access, with positive and significant coefficients in 2001 and 2003. The cable coefficient was only significantly negative in 2001, with no significant impact on access in 2000 or 2003. According to table 2, a massive growth in cable capacity occurred after 2001. However, table 4 shows that growth among users has increasingly turned to DSL (Consumer Electronics Association 2006). Thus, the negative cable parameter estimate may reflect the fact that cable capacity was increasing but consumers were increasingly turning toward DSL at that time.

High-speed Access Decomposition Results

The results of the non-linear decomposition for high-speed access in 2000, 2001, and 2003 are presented in table 5. The first two rows of table 5 indicate the share of rural and urban households with high-speed Internet access, and the third shows the resulting "digital divide" for each of the three years of CPS data. The remainder of the table reports the individual contributions from rural–urban differences in education, income, other household characteristics, network externalities, and DCT infrastructure.

TABLE 4. Household Internet Connections by Type (%)

Month/Year	*Dial-up*	*Cable*	*DSL*	*Other*
March-06	36	30	30	4
July-03	60	22	13	5
October-00	74	15	4	7

Source: Consumer Electronics Association, 2006.
Note: DSL = digital subscriber lines.

TABLE 5. Logit Decomposition Results—High-speed Access, 2000–2003

	Year		
	2000	*2001*	*2003*
Urban Household Internet Access Rate	0.0547	0.1182	0.2501
Rural Household Internet Access Rate	0.0248	0.0430	0.1122
Rural/Urban Gap	0.0299	0.0752	0.1379
Contributions from Rural/Urban Differences in:			
Education Levels	0.0026	0.0038	0.0117
	8.7%	5.1%	8.5%
Income Levels	0.0081	0.0156	0.0314
	27.1%	20.7%	22.8%
Other Household Characteristics	0.0022	0.0052	0.0103
	7.4%	6.9%	7.5%
Network Externalities	0.0120	0.0175	0.0401
	40.1%	23.3%	29.1%
DCT Infrastructure	−0.0001	−0.0010	0.0084
	−0.3%	−1.3%	6.1%
All included variables	0.0248	0.0411	0.1019
	82.9%	54.7%	73.9%

Note: DCT = digital communication technology. Percentages indicate the contribution of each variable group to the rural/urban gap for that year.

The difference between rural and urban high-speed Internet access rates ranges from 3 percentage points in 2000 to 14 percentage points in 2003. As expected, differences in education and income levels explain a large portion of this gap. Lower levels of education in rural areas account for between 5 and 9 percent of the divide over these years, while lower income levels make up between 21 and 27 percent. Differences in other household characteristics consistently account for approximately 7 percent of the high-speed divide. However, given the results of the logit model, this could mask significant offsetting effects—such as the positive impact of a male household head and the negative impact of a black or Hispanic household head. Network externalities play the largest role in the high-speed divide, making up between 23 to 40 percent. Rural–urban differences in DCT infrastructure make up approximately 6 percent

TABLE 6. Logit Decomposition Results—High-speed Access, 2000–2003 (Reverse Order)

	Year		
	2000	*2001*	*2003*
Urban Household Internet Access Rate	0.0547	0.1182	0.2501
Rural Household Internet Access Rate	0.0248	0.0430	0.1122
Rural/Urban Gap	0.0299	0.0752	0.1379
Contributions from Rural/Urban Differences in:			
Education Levels	0.0039	0.0069	0.0171
	13.0%	9.2%	12.4%
Income Levels	0.0087	0.0177	0.0310
	29.1%	23.5%	22.5%
Other Household Characteristics	−0.0007	−0.0015	−0.0006
	−2.3%	−2.0%	−0.4%
Network Externalities	0.0132	0.0195	0.0438
	44.1%	25.9%	31.8%
DCT Infrastructure	−0.0003	−0.0015	0.0106
	−1.0%	−2.0%	7.7%
All Included Variables	0.0248	0.0411	0.1019
	82.9%	54.7%	73.9%

Note: DCT = digital communication technology. Percentages indicate the contribution of each group of variables to the rural/urban gap for that year.

of the high-speed divide in 2003, but actually slightly *increase* the divide in 2000 and 2001. The decompositions indicate that group differences in all of the included variables explain between 55 and 83 percent of the gap in high-speed access. This implies that a portion of the gap (between 17 and 45 percent) is left unexplained by the included variables and is attributable to parameter differences in rural or urban areas or variables not controlled for in the analysis.

The non-linearity of the logit model indicates that the results may be sensitive to the order in which the variables are included. To explore this possibility, table 6 reverses the order of the explanatory variables. Most of the estimates are very similar to those obtained with the original ordering; however, the impact of other household characteristics decreases from explaining around 7 percent in all years under the initial ordering to explaining –2 percent under the reordering. Additionally, the impact of education increases from between 5 to 9 percent to between 9 to 13 percent of the total gap. The total contribution remains the same in both cases because the sum of the individual contributions necessarily equals the right-hand side of equations 3 and 4. As Fairlie (2003) notes, the sensitivity of the order in which the variables are introduced is dependent on the initial location of the estimate on the logistic distribution and the movement of the estimate along the distribution by switching characteristics of rural and urban households. Fairlie suggests experimenting with the ordering to verify the robustness of the results. The order of variable introduction was randomly selected for twenty different decompositions, with all resulting estimates lying in the intervals created by the results in tabes 4 and 5. Thus, while some differences arise when the ordering is varied, the dominant factors remain the same in all years.

Discussion and Policy Implications

The existence of various digital divides in Internet access was initially documented by the Clinton administration in a series of reports entitled "Falling through the Net" (NTIA 1995, 1998, 1999). These reports laid the groundwork for initiatives focused on bridging the gaps between the "haves" and "have-nots." Historically, the primary course of action of the federal, state, and local governments to address the rural–urban digital divide has been to provide subsidies for DCT infrastructure in low-density regions (Leighton 2001; Kruger 2005). However, the decomposition results indicate that the presence of DCT infrastructure is not a major determinant of the rural–urban high-speed divide. Rather, differences in education and income, along with network externalities, are the most important contributors to the high-speed access divide.

Variations to the model demonstrate the robustness of these results. While the initial specification includes a variable for Internet access at work, differences in rural and urban *types* of work may also contribute to the high-speed divide. For instance, employees in the professional sector are more likely to see the benefits of high-speed Internet access at their work than are those in the production or construction sectors. To explore the contribution of rural–urban differences in occupation, the model was re-estimated with indicators for seven-sector occupations of the head of the household (professional, sales, service, construction, farm, production, and army). Rural–urban differences in these occupations accounted for approximately 6 to 7 percent of the high-speed gap over the three years in the study, but at the expense of other variables (mostly network externalities and other household characteristics). Hence, the total percentage of the rural–urban gap explained remained essentially unchanged. DCT infrastructure, meanwhile, continued to explain very little of the divide.

Since DCT infrastructure is often a necessary condition for residential high-speed access, the fact that exposure to capacity has little influence on access rates in most locations is somewhat puzzling. Concern exists that infrastructure may be partially captured in the network externalities measure, given that regional rates of high-speed access may partially reflect DCT infrastructure capacity. When the high-speed access model is re-estimated without the network externality measure, the contribution of DCT infrastructure *does* increase, but not dramatically. Under this alternative specification, differences in DCT infrastructure capacity make up 1, 4, and 8 percent of the high-speed divide in 2000, 2001, and 2003, respectively. Meanwhile, income differences continue to account for over 22 percent of the divide. A second related concern is that the aggregate nature of the DCT infrastructure measures may mask underlying local relationships between infrastructure and high-speed access. Data constraints do not allow us to fully address this concern, and further research is needed.

What the current analysis does suggest is that policies which promote infrastructure capacity in rural areas are, alone, unlikely to bridge the emerging gap in high-speed access. Public-private partnerships have been promoted in areas with low market-based private provision of infrastructure, notably in Europe (Bauer 2005) but also in the United States (Gillett, Lehr, and Osorio 2004; 2006). While such partnerships are illegal in some states in the United States (and typically opposed by private providers), they may offer a venue for the provision of wired facilities that are otherwise not economically viable. Results from this article, however, imply that rural demand for high-speed access also needs to be stimulated. Lower levels of income in rural areas depress demand, but policies to address general income discrepancies have historically found little public support. These income discrepancies may become even more pronounced in the immediate future, as recent findings indicate that cost-savings "bundles" of Internet, TV, and phone services are primarily being rolled out to affluent, population-dense areas with high potential for adoption (Knowledge Networks 2006). If these bundles do increase rates of Internet adoption, public policies (such as loans or tax breaks) to speed their deployment in rural areas is an option. However, the impacts of bundles on Internet penetration has yet to be documented and presents an avenue for further research. In the meantime, policies to increase residential high-speed adoption rates in rural areas may need to concentrate on more general demand stimuli. One option is technology centers, which have been found to be effective in diffusing knowledge about the Internet to low-income communities (Servon and Nelson 2001) as well as to rural communities (Gooding 2005). Our results, particularly the sizable roles of income and network externalities, suggest that such demand-oriented policies are likely to be an important component of efforts to bridge the rural–urban divide in high-speed access.

Appendix A
State-level Rates of High-speed Access: 2000, 2001, and 2003

	High-speed						
	2000		*2001*		*2003*		
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	
Maine	3.32	9.86	6.49	16.08	14.37	26.64	
New Hampshire	3.52	8.71	9.90	19.04	24.03	36.39	
Vermont	1.42	7.00	7.33	17.50	13.53	34.08	New England
Massachusetts	0.00	8.40	3.19	15.72	19.66	30.40	
Rhode Island	N/A	5.96	N/A	12.56	N/A	27.96	
Connecticut	N/A	4.85	N/A	14.55	N/A	30.21	
New York	5.59	5.38	6.52	14.55	21.42	27.12	
New Jersey	N/A	5.97	N/A	13.42	N/A	31.62	Middle Atlantic
Pennsylvania	0.73	4.07	8.63	9.34	9.38	23.44	
Ohio	1.50	4.91	3.00	9.25	9.17	20.82	
Indiana	3.67	4.36	2.88	6.58	6.01	14.95	
Illinois	0.00	3.32	0.59	7.95	11.90	22.09	East North Central
Michigan	2.45	6.13	1.82	11.78	5.78	24.88	
Wisconsin	2.48	2.29	5.14	7.02	12.90	24.63	
Minnesota	3.20	5.62	3.64	9.96	14.21	24.15	
Iowa	2.60	6.23	6.67	13.24	14.41	25.90	
Missouri	1.78	7.61	4.67	10.13	7.76	22.39	
North Dakota	1.42	3.47	1.43	9.51	14.05	25.29	West North Central
South Dakota	1.97	4.39	8.57	14.28	19.31	30.85	
Nebraska	3.97	5.57	3.30	15.76	9.62	31.89	
Kansas	1.12	7.50	2.71	15.62	12.84	30.75	
Delaware	6.19	6.50	1.33	9.70	8.82	19.31	
Maryland	N/A	5.11	N/A	11.20	N/A	24.18	
DC	N/A	4.15	N/A	8.51	N/A	24.24	
Virginia	0.93	3.50	5.65	8.63	11.19	24.00	
West Virginia	2.03	5.04	2.48	6.58	10.53	21.61	South Atlantic
North Carolina	3.93	4.14	5.97	8.90	11.91	24.63	
South Carolina	0.00	5.21	1.43	10.97	9.90	20.77	
Georgia	0.92	3.70	3.13	10.07	10.94	25.61	
Florida	2.95	6.16	1.13	12.03	4.97	22.20	
Kentucky	3.72	6.01	2.65	3.91	8.54	19.47	
Tennessee	3.94	5.23	9.33	11.39	11.61	25.41	
Alabama	1.24	2.65	4.58	6.66	9.26	19.14	East South Central
Mississippi	5.53	4.28	7.36	6.25	8.39	17.71	

(continued)

APPENDIX A. (continued)

	High-speed						
	2000		*2001*		*2003*		
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Region*
Arkansas	1.92	2.84	3.53	4.92	13.27	14.61	
Louisiana	0.94	5.03	1.64	7.46	3.26	14.44	
Oklahoma	4.44	7.47	2.97	11.58	10.55	17.88	West South Central
Texas	1.84	5.55	1.07	11.79	8.30	22.39	
Montana	1.60	4.04	2.74	6.42	9.24	14.90	
Idaho	1.99	3.75	5.03	13.22	13.39	18.03	
Wyoming	1.99	1.48	6.76	6.63	13.38	14.41	
Colorado	2.64	5.89	6.22	11.71	10.00	27.03	
New Mexico	1.41	6.67	2.70	3.18	4.37	10.76	Mountain
Arizona	0.00	7.40	6.55	15.45	16.81	25.87	
Utah	3.20	5.33	5.38	15.08	14.42	23.84	
Nevada	2.09	6.20	3.21	8.04	9.01	28.82	
Washington	3.63	6.53	1.17	15.89	13.66	32.91	
Oregon	2.40	3.96	8.30	12.49	12.58	22.53	
California	4.72	6.51	4.98	15.63	10.50	29.30	Pacific
Alaska	3.66	7.60	8.85	19.17	19.59	30.31	
Hawaii	0.00	8.63	7.30	26.29	27.09	32.27	

Appendix B

State-level Rates of DCT Infrastructure Capacity (Cable and DSL) 2000, 2001, and 2003

These numbers represent the percentage of rural/urban population within each state that had DSL or cable access within their city (for DSL) or county (for Cable) of residence.

	DSL						*Cable*						
	2000		*2001*		*2003*		*2000*		*2001*		*2003*		
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Region*
Maine	0.00	0.00	1.07	1.32	6.10	5.76	11.41	15.33	10.76	15.33	57.61	87.92	
New Hampshire	0.00	0.00	0.00	0.00	6.86	1.46	11.42	32.85	11.42	32.85	71.52	73.16	
Vermont	0.00	0.00	1.10	5.58	8.01	5.58	0.00	0.00	0.00	0.00	45.68	53.81	New England
Massachusetts	0.00	0.00	0.00	6.84	0.00	9.40	0.00	27.19	0.00	27.19	58.39	92.24	
Rhode Island	0.00	0.00	0.00	0.00	0.00	19.55	0.00	70.80	0.00	70.80	0.00	76.32	
Connecticut	0.00	0.00	0.00	0.00	39.62	73.32	24.25	34.24	24.25	34.24	100.00	89.56	
New York	0.00	2.70	1.67	3.61	7.18	30.44	0.00	13.10	0.00	13.64	12.00	96.78	
New Jersey	0.00	0.00	0.00	0.00	0.00	3.61	0.00	32.85	0.00	32.85	0.00	73.16	Middle Atlantic
Pennsylvania	1.40	2.62	1.44	5.72	11.85	11.73	14.68	29.67	14.68	38.16	55.03	57.65	
Ohio	13.00	6.90	14.15	26.85	39.63	41.59	4.62	22.01	6.02	22.01	72.97	70.59	
Indiana	3.13	16.86	5.49	47.80	27.17	61.35	18.51	14.59	18.70	18.65	80.86	56.79	
Illinois	4.67	32.75	4.67	54.32	12.09	39.20	1.46	22.68	6.13	40.57	25.12	85.79	East North Central
Michigan	4.55	0.68	4.55	18.61	10.26	20.62	18.21	40.42	18.21	45.16	47.57	70.56	
Wisconsin	0.00	1.03	1.98	24.10	28.20	38.05	1.37	2.11	1.51	1.08	71.35	75.91	
Minnesota	0.85	0.00	1.96	5.04	9.38	9.43	5.76	4.03	5.90	4.16	32.32	100.00	
Iowa	0.07	0.00	0.66	0.74	15.95	9.36	0.44	53.20	3.17	53.84	37.73	73.16	
Missouri	6.37	19.13	6.36	24.48	33.02	46.69	0.00	3.59	0.07	7.04	18.38	29.13	

North Dakota	0.00	0.00	1.71	0.00	47.77	1.78	0.52	30.10	0.78	30.10	48.42	87.67	West North Central
South Dakota	0.00	0.00	9.07	0.00	28.36	0.79	17.38	42.77	19.13	45.78	59.36	100.00	
Nebraska	0.00	0.00	1.41	0.00	9.70	1.34	0.00	76.12	0.29	76.23	48.29	81.34	
Kansas	1.37	48.25	1.37	8.68	41.56	49.65	5.17	7.48	6.64	12.21	54.20	76.24	
Delaware	0.00	0.00	0.00	9.48	0.00	9.48	0.00	80.18	0.00	80.18	19.08	90.10	
Maryland	0.00	0.00	0.00	16.09	0.00	17.48	0.00	40.95	0.00	40.95	41.44	68.52	
DC	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00	
Virginia	9.89	15.47	7.51	27.37	45.32	30.77	5.64	31.92	5.64	36.22	23.77	59.52	
West Virginia	0.00	0.00	0.00	0.33	6.71	39.65	0.00	0.00	0.00	21.34	36.81	61.88	South Atlantic
North Carolina	0.52	40.50	24.32	67.58	78.47	85.43	1.24	8.17	1.24	8.17	55.07	91.62	
South Carolina	3.82	24.35	4.33	45.86	59.78	61.44	8.45	15.33	8.45	15.89	93.14	57.68	
Georgia	0.00	29.08	2.16	51.68	70.86	75.17	1.30	46.11	6.62	46.47	29.74	53.68	
Florida	0.00	26.61	6.41	41.00	68.58	48.01	0.00	16.75	0.00	23.56	62.04	80.37	
Kentucky	7.78	19.20	8.91	35.84	60.90	53.88	0.73	60.14	0.73	60.47	15.67	70.24	
Tennessee	1.87	54.07	5.90	66.16	70.64	89.30	2.82	39.01	2.82	41.43	26.44	84.14	
Alabama	3.65	31.97	6.32	49.19	51.51	66.80	3.38	6.72	7.65	8.44	28.36	63.69	East South Central
Mississippi	1.16	23.02	1.16	37.35	73.75	72.70	4.26	7.45	7.23	11.78	28.05	56.23	
Arkansas	0.00	16.64	7.59	42.40	36.02	67.90	5.60	6.10	5.60	13.32	65.17	100.00	
Louisiana	3.56	38.63	6.90	52.98	74.39	74.14	0.00	33.47	0.00	34.54	47.30	70.16	
Oklahoma	0.00	56.88	3.36	50.51	30.91	56.63	0.88	0.00	0.88	0.91	31.18	93.67	West South Central
Texas	15.89	22.63	18.12	58.59	38.88	69.04	0.10	16.33	1.40	16.35	38.59	66.06	
Montana	0.00	0.00	14.47	0.00	25.44	26.51	0.49	0.00	0.49	0.00	10.74	55.94	
Idaho	2.56	5.80	2.56	5.80	8.66	5.80	0.32	0.00	0.32	0.00	49.45	54.01	
Wyoming	0.00	0.00	0.00	0.00	1.56	0.00	3.56	0.00	3.56	0.00	24.85	92.16	
Colorado	0.00	0.00	12.81	0.00	26.29	3.73	0.00	13.74	0.00	17.01	4.72	74.34	

(continued)

APPENDIX B. (continued)

	DSL						Cable						
	2000		*2001*		*2003*		*2000*		*2001*		*2003*		
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Region*
New Mexico	0.00	0.00	0.00	0.00	21.12	0.00	0.00	28.81	0.00	28.81	12.00	70.53	Mountain
Arizona	0.00	0.09	0.00	0.09	8.02	9.49	2.19	0.00	1.10	2.68	48.95	100.00	
Utah	0.00	0.00	4.44	0.00	12.44	0.44	0.00	2.98	0.00	2.98	0.18	46.37	
Nevada	4.96	53.97	5.70	57.34	5.70	62.78	4.22	69.61	4.22	69.61	65.79	97.50	
Washington	11.09	16.47	25.01	23.60	39.34	27.05	44.51	31.72	44.51	52.32	84.62	73.60	
Oregon	6.73	16.49	20.93	18.25	40.38	28.46	1.13	29.50	17.27	34.89	77.09	78.41	
California	11.74	75.68	27.37	83.34	31.88	83.33	10.24	23.02	10.24	25.37	54.35	64.39	Pacific
Alaska	0.00	0.00	14.15	85.53	33.30	85.53	1.38	0.00	1.38	0.00	100.00	13.19	
Hawaii	29.16	75.07	29.16	75.07	29.16	75.07	0.00	96.07	0.00	96.07	34.07	98.44	

Note: DCT = digital communication technology; DSL = digital subscriber lines.

NOTES

1. High-speed access, also called Broadband or advanced service, is defined by the Federal Communications Commission as 200 Kilobits per second (Kbps) (or 200,000 bits per second) of data throughput. All estimates, unless noted, are based on authors' calculations using Current Population Survey Computer and Internet Use Supplements from 2000, 2001, and 2003.

2. This article uses the 1993 U.S. Census designations of non-metropolitan and metropolitan counties to compare rural–urban area differences in residential Internet access. Metropolitan counties generally have populations greater than 100,000 (75,000 in New England) or a town or city of at least 50,000 and are referred to as urban areas. Non-metropolitan counties are those counties not classified as metropolitan and are referred to as rural areas.

3. The 2000 CPS questionnaire only differentiates between dial-up and higher speed connections. The 2001 and 2003 questionnaires include categories for DSL, cable, satellite, and wireless (all of which are considered high-speed for the purposes of this article).

4. Household heads were identified by selecting the household member with the highest level of education; in cases where two or more individuals had the same level of education, the oldest member was selected.

5. Data on city/county population levels is taken from the 2000 census, provided by the Bureau of Labor Statistics.

6. Other sources of data on DCT infrastructure also exist, such as FCC form 477. This form requires all high-speed providers with more than 250 subscribers to file information regarding the number of lines serviced and the ZIP codes where service is provided. Form 477, however, does not differentiate between various types of high-speed service (i.e. cable, DSL, wireless, and satellite) and may give the impression that "wired" infrastructure (DSL and cable) exists when in fact it does not. Furthermore, the presence of DCT infrastructure in an area with less than 250 subscribers would not show up on Form 477 data.

7. The logit model had several benefits over alternative binomial variable statistical models—namely, that it restricts outcomes to the [0,1] interval (unlike the Linear Probability Model) and provides a closed form solution (unlike the probit model).

8. Monthly costs for high-speed access in 2000 are lower than expected, perhaps because of incentive programs employed by DSL and cable companies to attract customers.

9. The explanation of the decomposition includes only three variables (X_i, $D1_i$, and N_i) to save space. The actual decomposition will use all variables included in equation 1.

10. Note that since a pooled sample is used to obtain coefficient estimates, the decomposition uses weighted averages of the parameter estimates shown in equations 3 and 4.

11. Because of the non-linear form of the logit model, the contributions of X_i, $D1_i$, and N_i depend on values of the other variables. Hence, the order in which the variables enter equations 3 and 4 may affect their individual contributions to the rural–urban digital divide. To account for this, the order in which variables enter the analysis will be varied and the results will be compared.

REFERENCES

Bauer, J. 2005. Regulation and state ownership: Conflicts and complementarities in EU telecommunications. *Annals of Public and Cooperative Economics* 76: 151-77.

Bimber, B. 2000. Measuring the gender gap on the Internet. *Social Science Quarterly* 81: 868-76.

Blinder, A. 1973. Wage discrimination: Reduced form and structural variables. *Journal of Human Resources* 8: 436-55.

Chakraborty, J., and M. Bosman. 2005. Measuring the digital divide in the United States: Race, income, and personal computer ownership. *The Professional Geographer* 57: 395-410.

Consumer Electronics Association. 2006. Broadband and the home of tomorrow—March 2006. Used with Permission.

Cooper, M., and G. Kimmelman. 1999. The digital divide confronts the Telecommunications Act of 1996. Washington DC: Consumer Federation of America.

Downes, T., and S. Greenstein. 2002. Universal access and local Internet markets in the US. *Research Policy* 31: 1035-52.

Fairlie, R. 2003. An extension of the Blinder-Oaxaca decomposition technique to logit and probit models. *Economic Growth Center: Yale University.* Paper Number 873.

Federal Communications Commission (FCC)—Industry Analysis and Technology Division. 2004. *High speed services for Internet access: Status as of June 30, 2004*. Available at http://www.fcc.gov/wcb/iatd/comp.html

Fellows, D. 2005. *How women and men use the Internet*. Pew Internet & American Life Project. http://pewinternet.org/

Gillett, S., W. Lehr, and C. Osorio. 2004. Local Government Broadband Initiatives. *Telecommunications Policy* 28: 537-58.

———. 2006. Municipal electric utilities' role in telecommunication services. *Telecommunications Policy* 30: 464-80.

Gooding, H. 2005. Identifying critical factors for developing effective rural community technology centers. Unpublished Dissertation. West Virginia University, College of Human Resources and Education.

Graham, S., and A. Aurigi. 1997. Virtual cities, social polarization, and the crisis in urban public space. *Journal of Urban Technology* 4: 19-52.

Greenstein, S., and M. Lizardo. 1999. Determinants of the regional distribution of information technology infrastructure in U.S. In *The electronic village: Public policy issues of the information economy*, edited by Dale Orr and Tom Wilson. Toronto: C. D. Howe Institute.

Griliches, Z. 1957. Hybrid corn: An exploration in the economics of technological change. *Econometrica* 25: 501-22.

Grubesic, T., and M. O'Kelly. 2002. Using points of presence to measure accessibility to the commercial Internet. *The Professional Geographer* 54: 259-78.

Horrigan, J. B. 2001. *Online communities: Networks that nurture long-distance relationships and local ties*. Pew Internet & American Life Project. http://pewinternet.org/

———. 2004. *PEW Internet data project memo: Home broadband adoption has increased 60% in the past year and use of DSL lines is surging.* Pew Internet and American Life Project. http://pewinternet.org/

———. 2006. *Home broadband adoption 2006: Home broadband adoption is going mainstream and that means user generated content is coming from all kinds of Internet users*. Pew Internet and American Life Project. http://pewinternet.org/

Knowledge Networks, 2006. Spring 2006 ownership and trend report. *The Home Technology Monitor*. November.

Kruger, L. 2005. Broadband Internet access and the digital divide: Federal assistance programs. *Congressional Research Service—The Library of Congress*.

Leighton, W. A. 2001. Broadband deployment and the digital divide. Cato Policy Analysis No. 410. August 7.

Malecki, E. J. 2003. Digital development in rural areas: Potentials and pitfalls. *Journal of Rural Studies* 19: 201-14.

McConnaughey, J., and W. Lader. 1998. *Falling through the Net II: New data on the digital divide.* National Telecommunications and Information Administration, http://www.ntia.doc.gov/ntiahome/net2/falling.html

Mills, B. F. and B. Whitacre. 2003. Understanding the non-metropolitan–metropolitan digital divide. *Growth and Change* 34: 219-43.

Miniaci, R., and M. Parisi. 2006. Social interactions and the digital divide: Identification and policy implications. *Contributions to Economic Analysis and Policy* 5: article 29.

National Telecommunications and Information Administration (NTIA). 1995. *Falling through the Net: A survey of the "have nots" in rural and urban America.* Washington, DC: U.S. Department of Commerce.

———. 1998. *Falling through the Net II: New data on the digital divide.* Washington, DC: U.S. Department of Commerce.

———. 1999. *Falling through the Net: Defining the digital divide*. Washington, DC: U.S. Department of Commerce.

———. 2002. *A nation online: How Americans are expanding their use of the Internet.* Washington, DC: U.S. Department of Commerce.

Neumark, D. 1988. Employers discriminatory behavior and the estimation of wage discrimination. *Journal of Human Resources* 23: 279-95.

Oaxaca, R. 1973. Male-female differentials in urban labor markets. *International Economic Review* 14: 693-709.

Oaxaca, R., and M. Ransom. 1994. On discrimination and decomposition of wage differentials. *Journal of Econometrics*. 61: 5-21.

Pinkham Group. 2002. DSL deployment analysis of RBOCs and independent LECs in metropolitan and rural areas—Q4 2001. Available at http://www.dslprime.com/a/pinkham_deployment.htm

Prieger, J. 2003. The supply side of the digital divide: Is there equal availability in the broadband Internet access market? *Economic Inquiry* 41: 346-63.

Rose, R. 2003. *Oxford internet survey results.* Oxford, UK: The Oxford Internet Institute.

Servon, L, and M. Nelson. 2001. Community technology centers: Narrowing the digital divide in low-income, urban communities. *Journal of Urban Affairs* 23: 279-90.

Sinai, T., and J. Waldfogel. 2004. Geography and the Internet: Is the Internet a substitute or a complement for cities? *Journal of Urban Economics* 56: 1-24.

Strover, S. 2001. Rural Internet connectivity. *Telecommunications Policy* 25: 331-47.

Television and Cable Factbook, Cable and Services. 2000. Number 68: Cable Volumes 1-2. Washington, DC: Warren Publishing Inc.

———. 2001. Number 69: Cable Volumes 1-2. Washington, DC: Warren Publishing Inc.

———. 2003. Number 71: Cable Volumes 1-2. Washington, DC: Warren Publishing Inc.

Townsend, A. 2001. The Internet and the rise of the new network cities, 1969–1999. *Environment and Planning B: Planning and Design* 28: 39-58.