Growth and Change
Vol. 34 No. 2 (Spring 2003), pp. 219-243

Understanding the Non-Metropolitan–Metropolitan Digital Divide

BRADFORD F. MILLS AND BRIAN E. WHITACRE

ABSTRACT A consistent gap exists between home Internet use in metropolitan areas and in non-metropolitan areas in the U.S. This digital divide may stem from technology differences in home Internet connectivity. Alternatively, differences in education, income, and other household attributes may explain differences in metropolitan and non-metropolitan area home Internet access. Effective programs to reduce the metropolitan–non-metropolitan digital divide must be based on an understanding of the relative roles that technology and household characteristics play in determining differential Internet usage. The household Internet adoption decision is modeled using a logit estimation approach with data from the 2001 U.S. Current Population Survey Internet and Computer Use Supplement. A decomposition of separate metropolitan and non-metropolitan area estimates shows that differences in household attributes, particularly education and income, account for 63 percent of the current metropolitan–non-metropolitan digital divide. The result raises significant doubts that policies which focus solely on infrastructure and technology access will mitigate the current metropolitan–non-metropolitan digital divide.

Introduction

During the 1990s more and more households in the U.S. became "digitally connected" to the vast amount of information available on the Internet. Between December 1998 and September 2001 alone, the percentage of all households with Internet connections is estimated to have increased dramatically from 18.6 percent to 50.5 percent (NTIA 2002). Access to the Internet provides households with an array of previously unavailable opportunities for commerce, education, and entertainment. At the same time, disparities in access to, and use of, the Internet emerged among various segments of the population. Recent survey results show that whites have greater access to and use of the Internet than blacks (Compaine 2001; NTIA 2002). Non-Hispanics show greater use than Hispanics. More educated and higher income individuals also show greater Internet use (NTIA 2002). A gap has also been found to exist between metropolitan area and non-metropolitan area home use, with metropolitan area home use being about 12 percentage points higher in

Bradford F. Mills is an associate professor, and Brian Whitacre is a graduate research assistant in agricultural and applied economics at Virginia Polytechnic Institute and State University, Blacksburg, Virginia. *The authors acknowledge the helpful comments and suggestions of three anonymous reviewers.*

Submitted Apr. 2002; revised Oct. 2002.

Published by Blackwell Publishing, 350 Main Street, Malden MA 02148 US and 9600 Garsington Road, Oxford OX4 2DQ, UK.

2000 (Newburger 2001).[1] These inequalities in Internet use are generically referred to as the "digital divide." Concerns exist that the digital divide may exacerbate existing inequalities in household economic well-being (Drabenstott 2001).

Both the impact of the digital divide on future differences in economic well-being in metropolitan and non-metropolitan areas and appropriate policies to address the digital divide will depend on its underlying causes. If the divide stems from differences in the availability and quality of household Internet connectivity in metropolitan and non-metropolitan areas, it is unclear that market forces will act to reduce the divide. Evidence suggests that attempts to increase industry competition through the Telecommunications Act of 1996 have seen limited success in terms of creating incentives to expand infrastructure investments in lower density regions (Cooper and Kimmelman 1999; Warf 2001). Public policies, like infrastructure subsidies, may be necessary to ameliorate some spatial discrepancies in metropolitan–non-metropolitan area infrastructure (Parker 2000). A number of federal, state, and local initiatives have been developed to support infrastructure investments in low density regions. For example, the Rural Access Authority in North Carolina was created to provide local dial-up Internet access from every telephone exchange in the state. Other states like Washington and Virginia have also provided grants to rural areas to increase high-speed Internet access.

Alternatively, technology differences may not be the underlying source of the current metropolitan–non-metropolitan area digital divide.[2] Rather, differences in education, income, and other household attributes may drive differences in metropolitan and non-metropolitan region use. Income-based differences stem, in part, from the fact that Internet use is not an essential household good (Moss and Mitra 1998). But income and educational differences may be further intensified by the predominance of content targeted to high income and well educated groups. Available evidence suggests that there is less content on the Internet catering to the "underserved" population—those without household access (Children's Partnership Report 2000; Greenman 2000). For example, information on entry level jobs, low rent housing, and neighborhood assistance programs that is of particular use to low-income households is less likely to be posted on the Internet. As a result, the benefits from home Internet use of low-income households are low relative to the benefits derived by higher income households. Inequalities stemming from household attribute differences may also be intensified by the fact that the use of a local network increases the available benefits to all area network users (Graham and Aurigi 1997). Low income households tend to be geographically clustered. A household in a low income area is therefore likely to receive fewer benefits from home Internet use because a lower proportion of other households in the same geographic cluster are using the Internet.

If lower rates of household Internet use in non-metropolitan areas stem from lower income and education levels, efforts to close the divide may need to be linked to broader efforts to increase education and income levels in non-metropolitan areas. Ensuring children equal access to digital technology through schools also becomes essential in order to prevent the digital knowledge gaps from being passed on to the next generation. As mentioned, network externalities may also be particularly important in determining home Internet use. Lower propensities for households to use the Internet in non-metropolitan areas, given similar household characteristics and costs of access to the technology, may arise from lower aggregate use among peer groups. In this case concerted efforts to promote widespread use in specific areas thorough digital-villages or subsidized area user groups may be warranted.

The effective design of federal, state, and local programs to reduce the metropolitan–non-metropolitan area digital divide must be based on a sound understanding of the factors behind differential Internet access. While many studies have identified the general importance of attributes such as education and income in determining metropolitan and non-metropolitan household Internet use (e.g., McConnaughey et al. 1995; McConnaughey and Lader 1998; Cooper and Kimmelman 1999; NTIA 2000), research to date has not identified the relative roles that differences in attributes of households and place-based constraints play in explaining the metropolitan–non-metropolitan digital divide. This paper estimates a model of household Internet use and employs the results to test the relative importance of household attributes versus place-based differences in explaining the metropolitan–non-metropolitan digital divide. The results suggest that 63 percent of the current metropolitan–non-metropolitan digital divide stems from area differences in household attributes (particularly education and income), while 37 percent is associated with place-based differences in household behavior or regional attributes.

These results and the associated policy implications for reducing the metropolitan–non-metropolitan digital divide are developed in the remainder of the paper as follows. The next section describes the data used in the analysis. Descriptive statistics on household information technology use, characteristics, and economic conditions are provided for metropolitan and non-metropolitan area households, as well as for Internet users and non-users in metropolitan and non-metropolitan areas. The fourth section then develops a statistical model of the household Internet use decision. The fifth section presents model estimation results. The paper concludes with a discussion of the results and policy implications.

Data

Data on Internet use among metropolitan and non-metropolitan area households is obtained from the Current Population Survey (CPS), September 2001 Internet and Computer Use Supplement (U.S. Department of Commerce, Bureau of Census 2001).[3] The CPS is a sample of metropolitan and non-metropolitan households, and it is nationally representative when survey sample household weights are applied.[4] After dropping households with missing data there are 47,084 households included in the sample.

Home Internet use by a household is defined as a positive response to the Internet and Computer Use Supplement question “does anyone in the household connect to the Internet from home?” Descriptive statistics on rates of home use and household characteristics are provided in Table 1. Consistent with the results of previous studies like Newburger (2001) that have examined metropolitan–non-metropolitan differences in Internet access, a significantly higher share of metropolitan households (55 percent) use the Internet at home than non-metropolitan households (42 percent).[5] A similar percentage point gap in Internet use at work prevails (WORKUSE): 49 percent of metropolitan households have at least one adult member who uses the Internet at work versus 35 percent of non-metropolitan households.

TABLE 1. HOUSEHOLD CHARACTERISTICS BY METROPOLITAN-NON-METROPOLITAN RESIDENCE.

Description	Variable Name	Metro	Non-metro
Computer Characteristics			
Internet Service at Home (%)	internetuse	55.21	42.04*
Internet at Work (%)	workuse	49.23	35.07*
Household Characteristics			
Household Head Age (years)	age	47.13	50.01*
Household Head Education			
% with less than H.S. degree		14.32	20.05**
% with H.S. degree	hs	27.80	37.65**
% with some college	scoll	28.11	26.24**
% with a college degree or more	coll	29.77	16.06**
Family Structure			
Married	married	51.73	55.27**
Single Male-headed Household	umarrmale	18.97	16.80**
Single Female-headed Household	umnmarrfm	29.29	27.93**
1 Child under 16 in Household	chld1	14.54	14.02**
2 Children under 16 in Household	chld2	13.19	12.04**
3 Children under 16 in Household	chld3	4.93	4.93**
4 Children under 16 in Household	chld4	1.44	1.46**
5 Children (or more) under 16 in Household	chld5	0.44	0.56**
Racial Characteristics			
% White		81.79	89.57**
% Black	black	13.44	7.89**
% Other Race	othrace	4.77	2.54**
Ethnic—% Hispanic	hisp	10.91	4.55*
Employment / Income Characteristics			
% Employed	employed	83.16	76.32*
% with Business or Farm in Family	fambus	12.13	15.49*
% of Households making less than $5,000		3.02	4.39**
% of Households making $5,000-$7,499	faminc1	2.87	5.25**
% of Households making $7,500-$9,999	faminc2	3.09	4.50**
% of Households making $10,000-$12,499	faminc3	3.79	6.07**
% of Households making $12,500-$14,999	faminc4	3.46	5.42**
% of Households making $15,000-$19,999	faminc5	5.38	7.49**

TABLE 1. (CONTINUED)

Description	Variable Name	Metro	Non-metro
% of Households making $20,000-$24,999	faminc6	7.26	9.18**
% of Households making $25,000-$29,999	faminc7	6.60	8.15**
% of Households making $30,000-$34,999	faminc8	6.31	7.54**
% of Households making $35,000-$39,999	faminc9	6.14	6.79**
% of Households making $40,000-$49,999	faminc10	9.84	9.28**
% of Households making $50,000-$59,999	faminc11	9.14	8.36**
% of Households making $60,000-$74,999	faminc12	9.44	7.09**
% of Households making $75,000+	faminc13	23.66	10.49**
Household Location (Northeast = 0)			
Midwest	Midwest	21.35	31.47**
South	South	34.34	42.21**
West	West	24.67	15.83**

Note: * indicates means are significantly different at $p = 0.05$ level. ** indicates rejection of the null hypothesis that the categorical variables are from the same distribution at the $p = 0.05$ level. All means and variances are derived using survey sample weights.

Significant differences in metropolitan and non-metropolitan household characteristics also exist that may, in part, explain differential home Internet access. Household heads in non-metropolitan areas are, on average, older, and have lower levels of education, with 58 percent having no education beyond high school versus 42 percent in metropolitan areas. Household heads in non-metropolitan areas are more likely to be white and non-Hispanic. Non-metropolitan households are also more likely to be headed by a married couple and to have a business or farm that is run out of the household, but are less likely to have an employed adult living in the household. Finally, the distribution of household income also differs significantly in metropolitan and non-metropolitan areas. In non-metropolitan areas 50 percent of households reported annual incomes under $30,000, compared to only 35 percent in metropolitan areas. Similarly, 74 percent of non-metropolitan households reported incomes under $50,000 versus 58 percent of metropolitan households.

The potential contributions of these differences in metropolitan and non-metropolitan household attributes to the digital divide can be seen by comparing the characteristics of Internet users and non-users in metropolitan and non-metropolitan areas (Table 2). In both

TABLE 2. HOUSEHOLD CHARACTERISTICS BY METROPOLITAN–NON-METROPOLITAN AREA AND HOME INTERNET USE.

Characteristics	Variable Name	Metro Area		Non-metro Area		Total	
		Internet	No Internet	Internet	No Internet	Internet	No Internet
Household Characteristics							
Household Head Age	age	44.02	51.00*	45.38	53.38*	44.22	51.55*
Household Head Education							
% with less than H.S. degree		4.83	26.02**	6.46	29.92**	5.08	26.98**
% with H.S. degree	hs	21.53	35.52**	33.03	41.00**	23.29	36.81**
% with some college	scoll	31.23	24.27**	33.38	21.05**	31.56	23.51**
% with a college degree or more	coll	42.40	14.20**	27.11	8.03**	40.07	12.75**
Family Structure							
Married	married	63.78	36.89*	73.20	42.26*	65.22	38.15*
Single Male-headed Household	umarrmale	15.74	22.96*	10.53	21.34*	14.94	22.58*
Single Female-headed Household	umnmarrfm	20.49	40.14*	16.27	36.39*	19.84	39.26*
1 Child under 16 in Household	chld1	17.11	11.37**	18.58	10.71**	17.33	11.22**
2 Children under 16 in Household	chld2	16.56	9.03**	17.79	7.86**	16.74	8.76**
3 Children under 16 in Household	chld3	5.93	3.71**	6.35	3.90**	5.99	3.76**
4 Children under 16 in Household	chld4	1.48	1.38**	1.95	1.10**	1.55	1.31**
5+ Children under 16 in Household	chld5	0.46	0.42**	0.57	0.55**	0.47	0.45**

TABLE 2. (CONTINUED)

Characteristics	Variable Name	Metro Area		Non-metro Area		Total	
		Internet	No Internet	Internet	No Internet	Internet	No Internet
Racial Characteristics							
% White		85.80	76.85**	94.04	86.33**	87.07	79.08**
% Black	black	8.42	19.63*	3.75	10.89*	7.70	17.58*
% Other Race	othrace	5.78	3.52*	2.21	2.78*	5.23	3.34*
Ethnic Characteristics							
% Hispanic	hisp	6.77	16.01*	2.25	6.23*	6.08	13.71*
Household Location							
Northeast		19.99	19.23**	12.77	8.82**	18.88	16.79**
Midwest	midwest	20.92	21.87**	34.02	29.62**	22.92	23.69**
South	south	32.90	36.11**	35.81	46.86**	33.34	38.64**
West	west	26.20	22.78**	17.39	14.70**	24.85	20.88**

Note: * Indicates that the means are significantly different from each other at the $p = 0.05$ level. ** Indicates rejection of the null hypothesis that the categorical variables are from the same distribution at the $p = 0.05$ level.

areas, heads in households that use the Internet at home are younger, have higher levels of education, and are more likely to be married than are heads of households that do not use the Internet, while single female headed households are disproportionately represented among households that do not use the Internet at home. Households using the Internet at home in both areas are also more likely to have children at home and to have heads who are white and non-Hispanic.

The influence of household income and the employment of an adult member on home Internet use can be seen in Table 3. In both metropolitan and non-metropolitan areas, Internet using households are more likely to have an employed adult member and have higher incomes than are households that do not use the Internet. For example, in non-metropolitan areas over 68 percent of households that did not use the Internet at home had annual incomes below $30,000, compared to 26 percent of households that used the Internet at home. In both non-metropolitan and metropolitan areas, households that use the Internet at home are also more likely to have a member who uses the Internet at work. The next section develops a statistical model that identifies the contributions that these observed differences in the characteristics of metropolitan and non-metropolitan households make to the metropolitan–non-metropolitan digital divide.

A Model of Internet Use

The decision on whether or not to connect to the Internet at home is a discrete adoption choice for the household based on the household utility from adopting (U_1) and not adopting (U_0) the Internet. The utility a household derives will depend on the costs of home Internet use relative to the benefits. The household invests in Internet access if $U_1 > U_0$, and foregoes investment otherwise.

$$\text{Let } y_i^* = U_1 - U_0 = \beta' X_i + \varepsilon_i,$$

where X_i is a vector of household and place-based characteristics that influence the utility of home Internet access relative to no access, β' is the associated parameter vector, and ε_i is the associated error term. While y_i^* is a latent variable, it is observed that $y_i = 1$ if $y_i^* > 0$ (meaning the household invests in Internet use), and $y_i = 0$ otherwise. Hence

$$\text{Prob } (y_i = 1) = \text{Prob } (\varepsilon_i > -\beta' X_i), \text{ or Prob } (y_i = 1) = 1 - F(-\beta' X_i)$$

where F( ) is the cumulative distribution function for the error term ε_i. Each observed y_i is then the realization of a binomial process and the associated likelihood function can be expressed as

$$L = \prod_{yi=0} F(-\beta' X_i) \prod_{yi=1} [1 - F(-\beta' X_i)].$$

If the cumulative distribution of ε_i is the logistic, then

$$F(-\beta' X_i) = \exp(-\beta' X_i)/(1 + \exp(-\beta' X_i)) = 1/(1 + \exp(-\beta' X_i)), \text{ and}$$
$$[1 - F(-\beta' X_i)] = \exp(\beta' X_i)/(1 + \exp(\beta' X_i)).$$

The associated statistical model is estimated by the maximum likelihood method as

TABLE 3. EMPLOYMENT / INCOME CHARACTERISTICS BY METROPOLITAN–NON-METROPOLITAN AREA AND INTERNET USE.

Characteristics	Variable Name	Metro Area		Non-metro Area		Total	
		Internet	No Internet	Internet	No Internet	Internet	No Internet
% Employed	employed	91.86	72.43*	90.05	66.36*	91.59	71.00*
% using Internet at work	workuse	64.75	30.11*	54.86	20.71*	63.24	27.91*
% with Business or Farm in Family	fambus	16.69	6.51*	22.60	10.33*	17.59	7.41*
Income Characteristics							
% of Households making less than $5,000		1.22	5.23**	1.51	6.47**	1.27	5.52**
% of Households making $5,000-$7,499	faminc1	0.81	5.40**	1.13	8.24**	0.86	6.07**
% of Households making $7,500-$9,999	faminc2	0.89	5.81**	1.43	6.74**	0.97	6.03**
% of Households making $10,000-$12,499	faminc3	1.36	6.77**	2.80	8.44**	1.58	7.16**
% of Households making $12,500-$14,999	faminc4	1.25	6.19**	2.09	7.84**	1.38	6.58**
% of Households making $15,000-$19,999	faminc5	2.42	9.03**	3.61	10.31**	2.60	9.33**

TABLE 3. (CONTINUED)

Characteristics	Variable Name	Metro Area		Non-metro Area		Total	
		Internet	No Internet	Internet	No Internet	Internet	No Internet
% of Households making $20,000-$24,999	faminc6	4.30	10.90**	6.47	11.15**	4.63	10.96**
% of Households making $25,000-$29,999	faminc7	4.65	9.00**	7.02	8.96**	5.01	8.99**
% of Households making $30,000-$34,999	faminc8	5.43	7.40**	8.18	7.07**	5.85	7.32**
% of Households making $35,000-$39,999	faminc9	5.83	6.53**	7.47	6.30**	6.08	6.47**
% of Households making $40,000-$49,999	faminc10	10.78	8.68**	12.70	6.79**	11.08	8.24**
% of Households making $50,000-$59,999	faminc11	11.27	6.51**	12.99	5.00**	11.53	6.15**
% of Households making $60,000-$74,999	faminc12	12.98	5.08**	12.30	3.31**	12.87	4.66**
% of Households making $75,000 +	faminc13	36.79	7.48**	20.29	3.38**	34.27	6.52**

Note: * Indicates that the means are significantly different from each other at the $p = 0.05$ level.
** Indicates rejection of the null hypothesis that the categorical variables are from the same distribution at the $p = 0.05$ level.

$$\log L = \sum_{yi=0} \log[1/(1+\exp(\beta' X_i)] + \sum_{yi=1} \log[\exp(\beta' X_i)/(1+\exp(\beta' X_i)].$$

The explanatory variables in matrix X are grouped into three major categories (household attributes, household employment and income, and place-based) and discussed below.

Household attributes. The age (AGE) of the household head is likely to influence the propensity to use the Internet at home. All else equal, younger household heads are more likely to have been exposed to digital technologies in school and, therefore, more comfortable gaining access to the Internet from home. But the influence of age may not be linear, so a quadratic age (AGE2) term is also included in the model. Similarly, more educated household heads have greater exposure to digital technologies. As mentioned, more educated individuals may also be better served by Internet content. Household propensity to use the Internet is, therefore, expected to increase with the household head's level of education. On the other hand, Internet content may be less suited to the interests of households headed by blacks, other non-white racial groups (OTHRACE), and Hispanics (HISP), leaving them with a lower propensity to access the Internet at home, *ceteris paribus*.

Five discrete indicators for number of children in the family (CHLD1-CHLD5) are also included in the analysis. Children are likely to have both positive and negative effects on a households' propensity to use the Internet. Children are often exposed to computers and the Internet at school, thus increasing the household propensity to use the Internet from home. Further, with an additional child the benefits of Internet use are spread over an additional household member, while the cost of home Internet use is usually fixed. On the other hand, an additional child lowers the disposable income of the household, which decreases the household's propensity to use the Internet. The positive influence of an additional child on home Internet use is likely to initially outweigh the negative effect. Household propensity to use the Internet is, therefore, expected to increase with the number of children in the family, but the effect of an additional child is likely to decrease with family size.

Family structure may also influence home Internet use. Specifically, the propensity to use the Internet may be higher in households headed by married couples than for single male headed households (UNMARRMALE), as the costs of access are split between two adults. Early studies of Internet use also found females to have a lower propensity to use the Internet (Bimber 2000). However, more recent findings indicate the Internet gender gap has dissipated (NTIA 2002). An indicator for single female-headed households (UNMARRFM) is, however, included to test for a possible differential Internet use propensity among this family type relative to married couple and single male headed households.

Income and employment. Households with greater disposable income are likely more willing to purchase Internet connections for their homes. As mentioned, households with higher income may also derive greater benefits from home Internet use because the content is more matched to their needs and interests. Household propensity to use the Internet is, therefore, expected to increase with household income after controlling for household size through indicators for marriage and number of children. However the influence of income may not be linear, so thirteen discrete indicators of household income are employed (FAMINC1-FAMINC13) to demarcate increasing levels of household income. Households with an employed member may also be more likely to use the Internet at home. But the effect of employment on Internet use is likely much greater if an employed member of the household uses the Internet at work (WORKUSE) or if a family business is run from within the household (FAMBUS).

Place-based characteristics. A non-metropolitan area indicator variable (NONMET) is included in the model to test if a household's base propensity to use the Internet differs in metropolitan and non-metropolitan areas. As mentioned, propensities may differ across geographic areas for three reasons. First, metropolitan–non-metropolitan differences in propensities to use the Internet at home may stem from differences in the costs or quality of home Internet access. Second, differences in propensities may stem from differences in perceived benefits of home Internet use. For example, more information on local stores and businesses may be available in metropolitan areas. Alternatively, online shopping may be of greater value to non-metropolitan home users, given more limited selections of many goods in their immediate vicinity. Third, positive externalities from Internet use by other households in the area may increase Internet propensities for individual households in high use areas relative to low use areas.

Rates of home Internet use show a wide variation by area, with the highest rate of home Internet use found in the metropolitan West and the lowest rate found in the non-metropolitan South (Table 4). Two model specifications are estimated to capture geographic differences in household propensities to use the Internet at home. In the first specification, metropolitan and non-metropolitan South, Midwest, and West regional indi-

TABLE 4. HOME INTERNET USE BY REGION AND METRO—NON-METRO AREA.

	Homes Using Internet (%)
Northeast	
Metropolitan	56.15
Non-metropolitan	51.21
Midwest	
Metropolitan	54.09
Non-metropolitan	45.45
South	
Metropolitan	52.88
Non-metropolitan	35.67
West	
Metropolitan	58.63
Non-metropolitan	46.19

cators and a non-metropolitan Northeast indicator are included to allow propensities to use the Internet to fluctuate across region—metropolitan-non-metropolitan groupings relative to the Northeast metropolitan region. The strength of the relationship between regional rates of home Internet use and individual household propensities is later explicitly tested in a second model specification, where the percent of households using the Internet in each metropolitan–non-metropolitan region is included as an explanatory variable in place of the regional indicators.

In both model specifications parameter estimates for all household attributes, employment, and economic characteristics are also allowed to differ in metropolitan and non-metropolitan areas by including a non-metropolitan interaction term for each variable. The nature and magnitude of these non-metropolitan parameter shifts is left as an empirical question.

Results

Parameter estimates for the Logit adoption model are presented in Table 5. Column two presents parameter estimates for metropolitan households with associated standard errors presented in column three. Column four then presents the estimated shifts in parameters for non-metropolitan households relative to metropolitan household estimates. The results are discussed within the previously designated household attribute, household employment and income, and place-based characteristic variable groupings.

TABLE 5. LOGISTIC REGRESSION OF METRO–NON-METRO HOME INTERNET USE.

Variables	Metro		Non-metro	
	Coefficient	Standard Errors	Coefficient	Standard Errors
Household Head Characteristics				
age	0.0367**	0.0059	0.0200*	0.0120
age2	–0.0006**	0.0001	–0.0001	0.0001
hs	0.5970**	0.0538	0.0266	0.1112
scoll	1.1167**	0.0548	0.0639	0.1157
coll	1.4436**	0.0621	–0.0883	0.1393
collplus	1.5511**	0.0725	0.2006	0.1690
Family Structure				
unmarrmale	–0.5458**	0.0437	–0.2480**	0.0966
unmarrfm	–0.4590**	0.0386	–0.0663	0.0863
chld1	0.2114**	0.0469	0.1297	0.1003
chld2	0.2746**	0.0502	0.1943*	0.1084
chld3	0.3044**	0.0744	–0.1262	0.1531
chld4	0.2011*	0.1175	0.0956	0.2567
chld5	0.2640	0.2093	–0.4202	0.4246

TABLE 5. (CONTINUED)

Variables	Metro		Non-metro	
	Coefficient	Standard Errors	Coefficient	Standard Errors
Racial Characteristics				
black	–0.7736**	0.0466	0.2308	0.1462
othrace	0.1053	0.0758	–0.4573**	0.1888
Ethnic Characteristics				
hisp	–0.7197**	0.0546	0.0796	0.1743
Employment / Income Characteristics				
employed	–0.1113**	0.0507	0.0040	0.1081
workuse	0.5342**	0.0342	0.0377	0.0729
fambus	0.3158**	0.0497	–0.0698	0.0909
faminc1	–0.1423	0.1345	–0.1086	0.2605
faminc2	–0.1822	0.1332	0.2442	0.2707
faminc3	0.0068	0.1191	0.4077*	0.2350
faminc4	–0.0355	0.1228	0.0500	0.2476
faminc5	0.1275	0.1088	0.0136	0.2209
faminc6	0.3554**	0.1023	0.1594	0.2111
faminc7	0.5021**	0.1029	0.1117	0.2120
faminc8	0.7375**	0.1034	0.1066	0.2131
faminc9	0.8224**	0.1041	–0.0650	0.2171
faminc10	1.0014**	0.1004	0.1305	0.2103
faminc11	1.1974**	0.1017	0.0513	0.2147
faminc12	1.4347**	0.1040	0.0120	0.2213
faminc13	1.8000**	0.1006	–0.0183	0.2213
Household Location				
midwest	–0.2174**	0.0436	–0.0351	0.1058
south	–0.0471	0.0419	–0.3706**	0.1051
west	–0.0056	0.0459	–0.1406	0.1121
Intercept	–1.6228**	0.1666	–0.7693**	0.3645
Log-likelihood	–23,343.0			

Note: ** and * indicate statistically significant differences from zero at the $p = 0.05$ and $p = 0.10$ levels, respectively. Non-metropolitan coefficients represent shifts on metropolitan coefficients.

Household attributes. A household's propensity to use the Internet at home is found initially to be positively related to age in metropolitan areas. But the quadratic term is negative and the propensity reaches a maximum at thirty-one years of age and then declines. Non-metropolitan areas show a significantly different relationship between head's age and Internet use, as the propensity increases much more rapidly with age. As expected, a household's propensity to use the Internet at home also rises with the education level of the household head. But no significant difference in the influence of education on Internet use is found between metropolitan and non-metropolitan areas.

Family structure also influences home Internet use. In metropolitan areas, families headed by single males and single females show a lower propensity to use the Internet at home than families headed by married couples. It is also worth noting that single male headed families show a greater estimated negative association with Internet use than single female headed households and that the negative association with home Internet use is even stronger in non-metropolitan areas for single male headed households. The presence of children in the household is found to increase the propensity to use the Internet at home, but the positive influence appears to peak at three children. The positive influence of the first and second child on home Internet use is also found to be slightly stronger in non-metropolitan areas.

As in previous studies, metropolitan and non-metropolitan households headed by blacks and Hispanics show sharply lower propensities to use the Internet from home relative to whites and non-Hispanics, respectively. Households headed by other non-white racial groups do not show a significantly different propensity to use the Internet in metropolitan areas, but show a lower propensity to use the Internet at home in non-metropolitan areas.

Household employment and income. Internet access at work (WORKUSE) and having a family business (FAMBUS) increase the likelihood of using the Internet at home in both metropolitan and non-metropolitan areas. As expected, the propensity to use the Internet at home also increases with household income levels above $20,000 per year (FAMINC5). However, no significant metropolitan–non-metropolitan differences in the influence of income on home Internet use are identified. Contrary to expectations, the probability of home Internet use is found to decrease if an adult member of the household is employed. The negative association between household head employment and home Internet use, after controlling for household income and other factors, may stem from the generally lower socio-economic status of households who do not have a member with access to the Internet at work, rather than a mitigating influence of employment on the propensity of households to use the Internet at home.

Place-based characteristics. The base propensity to use the Internet at home also varies between metropolitan and non-metropolitan areas. The non-metropolitan area intercept term is negative, indicating that the base propensity to use the Internet is lower in non-metropolitan areas than metropolitan areas after controlling for household personal and economic characteristics. There is also a significant variation in home Internet use within metropolitan and non-metropolitan areas by region. In metropolitan areas, households in the Midwest show a significantly lower propensity to use the Internet than do households in the Northeast after controlling for differences in household characteristics. In non-metropolitan areas, households in the South show a significantly lower propensity to use the Internet at home than in the Northeast, *ceteris paribus*.

Discussion

Only a handful of the estimated non-metropolitan area parameter shifts are statistically significant. This suggests that metropolitan–non-metropolitan area difference in specific household attribute influences on propensities to use the Internet at home may not be driving the observed gap in home use. On the other hand, a comparison of the log-likelihood of the model against an alternative model where metropolitan and non-metropolitan parameters on each variable are constrained to be equal suggests that, when the parameters are taken as a group, differences in metropolitan and non-metropolitan Internet adoption behavior are statistically significant at the $p = 0.05$ level (for results see Appendix 1).[6] The importance of these structural differences in metropolitan–non-metropolitan Internet adoption behavior is further explored by decomposing the metropolitan–non-metropolitan gap in home Internet use into the component associated with metropolitan–non-metropolitan parameter differences and the component associated with differences in underlying household attribute, employment, and income variables.

Since the Logit estimator is non-linear, the standard Oaxaca-Blinder decomposition method cannot be used (Oaxaca 1973). Instead, Nielsen (1998) is followed in implementing a generalized decomposition made up of three simulated probabilities

$$\hat{P}_u = \sum_{i=1}^{N_u} F\left[X_{ui}\hat{B}\right] / N_u$$

$$\hat{P}_r = \sum_{i=1}^{N_r} F\left[X_{ri}\left(\hat{B}+\hat{\delta}\right)\right] / N_r$$

$$\hat{P}_r^0 = \sum_{i=1}^{N_r} F\left[X_{ri}\hat{B}\right] / N_r$$

where $\hat{P}_u$ and $\hat{P}_r$ are the average probabilities of Internet use among metropolitan and non-metropolitan households, respectively. N_u is the sample size for metropolitan households and N_r is the sample size for non-metropolitan households. $\hat{B}$ is the estimated parameter vector for metropolitan households and $\hat{\delta}$ is the estimated shift for non-metropolitan household parameters relative to metropolitan household parameters. $\hat{P}_r^0$ is calculated for each non-metropolitan household as the probability of Internet adoption with metropolitan parameter estimates.

The metropolitan–non-metropolitan household Internet use gap $\left(\hat{P}_u - \hat{P}_r\right)$ is then divided into the component associated with metropolitan–non-metropolitan household attribute difference differences $\left(\hat{P}_u - \hat{P}_r^0\right)$ and the component associated with difference in underlying parameters, or behavioral differences $\left(\hat{P}_r^0 - \hat{P}_r\right)$, including differences in regional propensities. The results of the decomposition are shown in Table 6. Consistent

TABLE 6. LOGIT DECOMPOSITION.

Variable	Description	Percent	Gap to P_u	Share of Gap (%)
P_u	Urban parameters and urban sample	55.20		
P_r^o	Urban parameters and rural sample	46.45	8.27	62.90
P_r	Rural parameters and rural sample	42.05	4.88	37.10

with the results in Table 1, $\hat{P}_u$ is calculated as 55.2 percent and $\hat{P}_r$ as 42.1 percent, while $\hat{P}_r^0$ is calculated as 46.5 percent. Thus of the total 13.1 percentage point gap in metropolitan and non-metropolitan household Internet use, 8.3 percentage points (63 percent) is associated with differences in household characteristics and 4.9 percentage points (37 percent) is associated with place-based differences in adoption behavior. This result clearly indicates that underlying household attribute differences between metropolitan and non-metropolitan areas go a long way towards explaining the current digital divide.

Most of the behavioral differences in metropolitan–non-metropolitan Internet decisions stem from differences in the non-metropolitan intercept term and region specific indicator variables. As mentioned, the factors underlying the large negative non-metropolitan intercept shift in the propensity to adopt the Internet may stem from several sources. The shift might be related to metropolitan–non-metropolitan differences in the costs of Internet access, but data available from the CPS 2000 Internet and Computer Use Supplement indicates that the average monthly amount paid by households for Internet service in metropolitan areas ($17.81) is essentially the same as that paid in non-metropolitan areas ($17.31) (Table 7).

Similar average access costs may, however, mask metropolitan–non-metropolitan differences in telecommunications infrastructure. Important differences in digital infrastructure do exist in metropolitan and non-metropolitan areas. Greenman (2000) reports that less than one percent of towns with under 10,000 persons have digital subscriber line services or cable modem services. On the other hand, 86 percent of cities over 100,000 persons have digital subscriber line services and 72 percent of cities with more than 250,000 persons have cable modem services. While not focusing on broadband access, Gabe and Abel (2002) find that in 1999 major telecommunication carriers had considerably more integrated services—digital network lines that support high speed data transmission in metropolitan areas than in non-metropolitan areas. Further, this gap appears to be growing. Downes and Greenstein (1998) find that Internet Service Providers are highly concentrated in urban areas. Metropolitan–non-metropolitan area differences in high-speed Internet access may influence the quality of Internet service that is provided at a given price (Malecki 2001).

TABLE 7. METRO–NON-METRO DIFFERENCES IN QUALITY OF INTERNET ACCESS AMONG USERS.

	Non-metropolitan	Metropolitan
Cost per Month ($)[a]	17.31	17.81*
Type of Internet Access (%)		
Regular Dial-up	90.08	79.07*
High Speed	9.92	20.93*
High-Speed Use by Region (%)		
Northeast	12.99	22.56**
Midwest	7.47	16.25**
South	9.88	18.11**
West	8.39	23.05**
Long Distance Access (%)		
Local Provider	94.91	96.36*
Long Distance Provider	5.09	3.64*

Note: [a] Cost per month data is from 2000 CPS Internet and Computer Use Supplement.
* indicates that the means are significantly different from each other at the $p = 0.05$ level.
** indicates rejection of the null hypothesis that the categorical variables are from the same distribution at $p = 0.05$ level.

The CPS 2001 data also provide some evidence that technology infrastructure differences may be contributing to the place-based component of the metropolitan–non-metropolitan digital divide. Survey data indicate that 9.9 percent of non-metropolitan household Internet users had high-speed connections compared to 20.9 percent of metropolitan users (Table 7). This high-speed connection gap also varies by region—it is the largest in the West, where the percentage of metropolitan users with high-speed access is over twice that of non-metropolitan users.[7] It is also worth noting that non-metropolitan users are only slightly more reliant on long-distance carriers to obtain Internet access, suggesting that additional carrier costs for Internet access are not significantly higher in non-metropolitan areas.

Regional differences in Internet use may also arise, in part, from positive network externalities in regional Internet use. Given the strong local base concentration of many on-line communities (Horrigan et al. 2001), the value of the Internet to a household in the region may increase as the share of other connected households (and businesses) in the region increases.[8] Results from the second model specification that includes a variable measuring the share of households with Internet access in each region (REGDENSITY) are presented in Table 8. The regional density parameter coefficient is positive and

TABLE 8. LOGISTIC REGRESSION USING REGIONAL DENSITY.

Variables	Metro		Non-metro	
	Coefficient	Standard Errors	Coefficient	Standard Errors
Household Head Characteristics				
age	0.0365**	0.0055	0.0201*	0.0120
age2	–0.0006**	0.0001	–0.0001	0.0001
Hs	0.5940**	0.0536	0.0339	0.1111
Scoll	1.1127**	0.0547	0.0713	0.1153
Coll	1.4463**	0.0621	–0.0891	0.1389
Collplus	1.5539**	0.0725	0.2012	0.1688
Family Structure				
Unmarrmale	–0.5481**	0.0436	–0.2370**	0.0962
Unmarrfm	–0.4635**	0.0386	–0.0571	0.0860
chld1	0.2106**	0.0468	0.1313	0.1001
chld2	0.2717**	0.0502	0.1996*	0.1083
chld3	0.2920**	0.0740	–0.1117	0.1530
chld4	0.1893	0.1171	0.1133	0.2565
chld5	0.2484	0.2089	–0.3908	0.4200
Racial Characteristics				
Black	–0.7531**	0.0462	0.1795	0.1431
Othrace	0.1143	0.0751	–0.4652**	0.1872
Ethnic Characteristics				
Hisp	–0.6932**	0.0536	0.0438	0.1719
Employment / Income Characteristics				
Employed	–0.1137**	0.0507	0.0057	0.1080
Workuse	0.5317**	0.0342	0.0431	0.0728
Fambus	0.3204**	0.0497	–0.0735	0.0906
faminc1	–0.1391	0.1345	–0.1129	0.2605
faminc2	–0.1826	0.1332	0.2426	0.2706
faminc3	0.0082	0.1190	0.4074*	0.2348
faminc4	–0.0319	0.1227	0.0479	0.2475
faminc5	0.1290	0.1088	0.0157	0.2207
faminc6	0.3547**	0.1022	0.1631	0.2111
faminc7	0.5012**	0.1027	0.1141	0.2118
faminc8	0.7370**	0.1033	0.1104	0.2130
faminc9	0.8215**	0.1039	–0.0617	0.2169
faminc10	0.9998**	0.1003	0.1330	0.2102
faminc11	1.1926**	0.1016	0.0557	0.2146

TABLE 8. (CONTINUED)

Variables	Metro		Non-metro	
	Coefficient	Standard Errors	Coefficient	Standard Errors
faminc12	1.4268**	0.1038		0.2210
faminc13	1.8003**	0.1006	–0.0172	0.2167
Regional Density				
Regdensity	1.6882**	0.3792		
Intercept	–2.6171**	0.2647	–0.7746**	0.3574
Log-likelihood	–23,364.4			

Note: ** and * indicate statistically significant differences from zero at the $p = 0.05$ and $p = 0.10$ levels, respectively. Non-metropolitan coefficients represent shifts on metropolitan coefficients.

significant, indicating that regional rates of Internet use do have a positive association with individual households' propensities to use the Internet. It is also instructive to compare the results from the decomposition of this alternative specification with the results from the initial specification. In the second model regional density differences are now part of the household attribute portion of the decomposition $\left(\hat{P}_u - \hat{P}_r^0\right)$, while under the initial specification they were captured as part of the behavioral difference component $\left(\hat{P}_r^0 - \hat{P}_r\right)$ through regional intercepts. As a result, attribute differences under the alternative specification account for 91.2 percent of the metropolitan–non-metropolitan gap in home Internet use. In other words, differences in household attributes and regional rates of household Internet use appear to account for almost the entire metropolitan–non-metropolitan digital divide.

Conclusions

Some have suggested that regional differences in Internet use will dissipate over time as part of a normal pattern of core to periphery spatial diffusion (Compaine 2001). The findings in this paper lead to a less optimistic conclusion about the persistence of the gap in metropolitan–non-metropolitan rates of home Internet use. Differences in metropolitan–non-metropolitan household attributes account for almost two-thirds of the current gap and these differences, particularly in education and income levels, are unlikely to dissipate rapidly. Metropolitan–non-metropolitan differences in education and income levels are also associated with lower levels of economic well-being in non-metropolitan areas. Thus, gaps in home Internet use are likely to show some of the persistence that metropolitan–non-metropolitan differences in economic well-being have shown.

Place-based differences account for about one-third of the remaining metropolitan–

non-metropolitan gap. A portion of place-based differences may stem from lower levels of infrastructure in non-metropolitan areas to support high-speed Internet access. Market forces unleashed by the 1996 Telecommunications Act have not generated hoped for infrastructure investments in non-metropolitan areas. The weight given to metropolitan–non-metropolitan infrastructure differences in explaining the place-based component of the digital divide needs, however, to be tempered by the fact that an overwhelming majority of households in both metropolitan and non-metropolitan areas connect to the Internet using a dial-up modem and a local phone line. Regional densities of home Internet use also appear to be strongly associated with individual household decisions and can account for almost the entire place-based component of the metropolitan–non-metropolitan gap.

Further research is needed to disentangle the underlying causes of differing regional rates of household Internet use, particularly the roles that regional infrastructure differences, network externalities, and other factors play. As part of this effort, data that provide a more spatially sensitive classification than metropolitan–non-metropolitan may be required. For example, even after controlling for differences in household characteristics, the causes of low propensities for home Internet use in the Appalachia and the Mississippi Delta regions of the non-metropolitan South are likely to differ. Still, the importance of attribute differences in explaining the metropolitan–non-metropolitan divide and the limited prevalence of high speed access in both metropolitan and non-metropolitan area households, combined, raise significant doubts that policies which focus solely on infrastructure and technology access will mitigate the current metropolitan–non-metropolitan digital divide.

Policy options to address the household attribute component of the metropolitan—non-metropolitan digital divide must be linked to broader efforts to address income and educational disparities. Unfortunately, market forces have shown little tendency to dissipate such social disparities and public support for initiatives to address social inequalities that underlie the digital divide is limited. Public support for measures to increase general access for underserved populations is also currently weak. In fact, the two major federal programs (Technology Opportunities Program and Community Technology Centers) with the mandate to increase the use of digital technologies among underserved populations are designated for elimination of funding (Harris and Associates 2002).

Given these trends, it is tempting to conclude little can be done to address the metropolitan–non-metropolitan digital divide and the social inequalities that underlie it. However, it is worth noting that public investments have successfully created relatively equal access to the Internet in the nation's schools, with Internet use among children 6 to 17 years of age at school far more equal across race and income groups than use at home (Newburger 2001; NTIA 2002). Similarly, analysis of the CPS data indicates that the rate of Internet use at school is higher in non-metropolitan areas than in metropolitan areas. Ensuring access to digital technologies at school is essential if the current digital divide is not to leave an intergenerational legacy. Whether a similar commitment should be made to address existing disparities among the adult population is a political choice.

APPENDIX 1. LOGISTIC REGRESSION METRO–NON-METRO PARAMETERS EQUAL.

Variables	Coefficient	Standard Errors
Household Head Characteristics		
age	0.0384**	0.0049
age2	–0.0006**	0.0000
Hs	0.6035**	0.0470
Scoll	1.1391**	0.0482
coll	1.4555**	0.0554
collplus	1.5986**	0.0654
Family Structure		
unmarrmale	–0.5657**	0.0386
unmarrfm	–0.4517**	0.0343
chld1	0.2262**	0.0414
chld2	0.3036**	0.0444
chld3	0.2595**	0.0651
chld4	0.2115**	0.1045
chld5	0.1427	0.1798
Racial Characteristics		
black	–0.7175**	0.0438
othrace	0.0729	0.0689
Ethnic Characteristics		
hisp	–0.6686**	0.0513
Employment / Income Characteristics		
employed	–0.1181**	0.0448
workuse	0.5510**	0.0302
fambus	0.2892**	0.0142
faminc1	–0.1736	0.1157
faminc2	–0.1248	0.1157
faminc3	0.1094	0.1022
faminc4	–0.0166	0.1063
faminc5	0.1441	0.0946
faminc6	0.4113**	0.0893
faminc7	0.5461**	0.0897
faminc8	0.7871**	0.0902
faminc9	0.8390**	0.0911
faminc10	1.0648**	0.0879
faminc11	1.2458**	0.0893
faminc12	1.4872**	0.0915
faminc13	1.8557**	0.0886

APPENDIX 1. (CONTINUED)

Variables	Coefficient	Standard Errors
Household Location		
midwest	–0.2342**	0.0392
south	–0.1309**	0.0379
west	–0.0286	0.0418
midwest	–0.2342**	0.0392
Intercept	–1.7632**	0.1477
Log-likelihood	–23,422.6	

Note: ** and * indicate statistically significant differences from zero at the p = 0.05 and p = 0.10 levels, respectively.

NOTES

1. This paper uses 1993 U.S. Census designations of non-metropolitan and metropolitan counties to compare metropolitan–non-metropolitan area differences in home Internet use. Metropolitan counties generally have populations greater than 100,000 (75,000 in New England) or a town or city of at least 50,000. Non-metropolitan counties are those counties not classified as metropolitan. Under the alternative urban—rural distinction (with "urban" areas having a total population density of at least 1,000 persons per square mile and a total population of at least 50,000, as well as cities, boroughs, and towns, and other census areas having 2,5000 or more persons) the gap in home Internet use is much smaller (NTIA 2002).
2. A reviewer points out that technology and household attribute differences may be complementary, and not mutually exclusive, components of metropolitan and non-metropolitan area differences in home Internet use.
3. The CPS Internet Use Supplement is the main source for national statistics on home Internet use. The Pew Internet and American Life Project provides an alternative national dataset with largely similar descriptive statistics, see Lenhart et al. 2000.
4. Survey household sample weights are used to derive all statistics in the subsequent analysis.
5. All differences are statistically significant at the p = 0.05 level unless otherwise noted.
6. Log-likelihood tests allowing place-based characteristic parameter estimates to vary in metropolitan and non-metropolitan areas, but constraining household attributes, employment, and income variable parameter estimates to be the same, also indicate significant structural differences arise from household attribute, employment, and income parameter estimates alone.
7. High-speed access is more important for many business applications than home applications. Other infrastructure differences may also contribute to slower Internet performance in some non-metropolitan areas (Greenman 2000).
8. As a reviewer points out, n users generate $n(n - 1)/2$ potential connections.

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