IOWA STATE UNIVERSITY

Broadband Access, Telecommuting and the Urban-Rural Digital Divide

Moohoun Song, Peter Orazem, Rajesh Singh

February 2006

Working Paper # 06002

Department of Economics Working Papers Series

Ames, Iowa 50011

Broadband Access, Telecommuting and the Urban-Rural Digital Divide

Moohoun Song[a], Peter F. Orazem[b] and Rajesh Singh[b]

February 2006

A unique data set on home use of computers and the Internet is used to investigate the tradeoffs between physically commuting to a work site and telecommuting from home via computers. The study further investigates whether individuals who work from home receive greater compensation relative to their neighbors who do not telecommute, potentially because the Internet allows more remotely located workers to access higher paid labor markets. These questions are investigated separately over samples of urban and rural workers to determine if incentives to telecommute differ between more- and less-densely populated areas. Results show that telecommuting responds positively to local average commuting time and to local access to High-Speed Internet service. Differences in broadband access explain three-fourths of the gap in telecommuting between urban and rural markets. Correcting for endogeneity, telecommuters and other IT users do not earn significantly more than otherwise observationally comparable workers. Instead, it is the already highly skilled and highly paid workers that are the most likely to telecommute, not that they earn more because they telecommute. The results suggest that as broadband access improves in rural markets, the urban-rural gap in telecommuting will diminish. The urban-rural pay gap may also decrease if improved broadband access induces some already highly paid urban workers to move to rural areas.
JEL: O18, O33, J31

---

[a] Korea Energy Economics Institute
[b] Iowa State University, Department of Economics, Ames, IA 50011-1070.
Corresponding author is Rajesh Singh, rsingh@iastate.edu (515) 294-5213
We gratefully acknowledge the help of Dr Michael Suman and the UCLA Center for Communication Policy for adding telecommuting questions to their Internet survey and for providing the data to us.

Broadband Access, Telecommuting and the Urban-Rural Digital Divide

I. Introduction

There is widespread agreement that the dissemination of information technologies (IT) has contributed to U.S. economic growth since the mid 1990s (Jorgensen (2001), Litan and Rivlin (2001), Blinder (2000)). There is also evidence that differential adoption of information technologies across skill groups and industries may have led to rising wage inequality in the U.S. (Acemoglu (2002), Autor, Katz and Kruger (1998), Oliner and Sichel (2000), Dunne et al (2004).

There is less consistent evidence at the individual level that workers using computers earn more than those who don't. When computer or IT use is treated as exogenous, studies generally find large positive returns (Krueger (1993), Lee and Kim (2004), DiNardo and Pischke (1997)) although the latter found similarly large returns to other office equipment. Studies that control either for unmeasured ability or for the endogeneity of computer usage tend to find smaller and sometimes negligible returns (Entorf et al (1999), Krashinsky (2004) Liu, Tsou and Hammitt (2004)).

To the extent that IT use does raise earnings for adopters, differential access to these technologies across races, genders, or regions threatens to broaden existing earnings gaps. Differences in IT technology adoption and/or use between races, education levels, and regions have been labeled the "Digital Divide." Previous studies have documented differences in adoption rates between the sexes, races, and education levels (NTIA (2000), Fairlie (2004)). However, most of these groups have similar access to technologies, at least as measured by their geographic proximity. Most forms of IT capital are mobile, and fixed IT infrastructure tends to be equally accessible to most demographic, education, and income groups (Prieger (2003)). A prominent exception is that High-Speed Internet access differs significantly across metropolitan and non-metropolitan markets (Gabe and Abel (2002) and Prieger (2003)).[1] This paper examines the impact of this differential access on urban-rural differences in IT adoption and telecommuting and their implications for the earnings of urban and rural workers.

Some definitions of telecommuting include overtime work from home, home-based self employment, and uses of fax, e-mail, and telephone to reach work-related distant parties. To isolate the impact of IT technologies on work location, we focus our telecommuting definition more narrowly on the use of computers and Internet for work at home. As in Mokhtarian, Salomon, and Choo (2005), we restrict our attention to salaried employees, and thus distinguish telecommuters from self-employed home-based business workers.

High-speed Internet access can change the location where people work because it is more compatible with business applications than are other types of Internet service. If employees can work from home without losing productivity relative to physically commuting to work, then broadband access should increase the likelihood of telecommuting. Incentives to telecommute should be greater as the time cost of physical commuting rises, suggesting that broadband access might be particularly important for expanding telecommuting in rural markets.

The reason broadband is more important for telecommuting than are other forms of Internet access is that broadband services are 10-30 times faster than other forms of narrowband access such as dial-up phone service. Consequently, many applications that are standard for broadband users are not available for narrowband subscribers. The differences in capacity and uses are so great that Hausman (2002) concludes that broadband and narrowband are not even in

[1] Throughout this paper we use the terms broadband and High-Speed Internet interchangeably. Providers of high-speed lines provide broadband services by means of several mutually exclusive types of technology. The two major types are asymmetric digital subscriber lines (DSL) and cable modems using hybrid fiber-coaxial cable networks that make up 34% and 58% of the market respectively. Other forms include satellite service and other forms of wired service.

the same product market. Even satellite services are inferior because, while they offer rapid download capacity, uploading requires the slower dial-up connection.

Our empirical evidence suggests that broadband access has a large impact on the incentives to work from home using computers and the Internet. These differences in access explain three-quarters of the gap in the probability of telecommuting between urban and rural labor markets. In addition, telecommuting probability increases as the average commuting length in the county increases. However, the incentives to telecommute are at least as great in urban as in rural markets, as the average commuting time is larger in urban than in rural areas. Our results suggest that broadband access is equally important in urban and rural markets in allowing the possibility of telecommuting. Consequently, as broadband continues to expand to rural markets, the gap in telecommuting between urban and rural areas should disappear.

Urban workers have a long-standing wage advantage over similarly skilled rural workers. One explanation is that urban workers are more productive because of externalities associated with agglomerations of human capital in cities (Moretti, 2004). High-speed Internet potentially allows more remotely located workers or firms to access the agglomerated human capital in urban markets.[2] If so, then it is plausible that rural residents who use the Internet for work could earn more than comparable workers who do not use the Internet.

When treated as exogenous, telecommuting and computer use at work are associated with very large and statistically significant earnings premiums. When IT adoption is treated as endogenous, the estimated returns become smaller and insignificant. These results suggest that highly skilled and highly paid workers may move to more remote areas because of broadband

[2] In recent years, the share of headquarters located in the five largest metropolitan cities in the US has been declining while the share of medium-sized cities has been on the rise. Improvements in information technology have been offered as one of the possible explanations (Klier and Testa (2002)). Insofar as headquarter jobs are likely to be more IT-intensive, their relocation to medium-sized cities may further enhance the geographical dispersion of skilled labor.

access, but that telecommuting does not raise earnings directly after controlling for the endogeneity. If this interpretation is correct, then expanded broadband access could raise average earnings in rural markets because it will facilitate inmigration of skilled and highly paid workers, even if it does not alter the earnings of those particular workers relative to what they would have earned in urban markets

II. An Empirical Model of Telecommuting

This section lays out the empirical strategy used to analyze how broadband access affects the incentives to telecommute and whether differential broadband access exacerbates or diminishes urban-rural wage differentials. To begin, if the adoption of information technologies for work either at home or at the office raises earnings, then $\gamma_2 > 0$ in a regression of the form

(1) $$y_i = X_i\gamma_1 + T_i\gamma_2 + u_i$$

where y_i is the logarithm of earnings received by individual i, X_i is a vector of individual demographic and human capital variables that affect earnings, and T_i is a dummy variable that takes the value of 1 if individual i uses information technologies for work. If T_i were exogenously determined, an equation such as (1) would yield unbiased estimates of γ_2. That is unlikely however. Information technologies are likely to be affected by individual labor market earnings. This is particularly true for information technologies used from home for telecommuting purposes as the technologies are expensive and involve recurring expenses to maintain software and internet capabilities. Furthermore, it is plausible that the types of jobs that are most complementary with telecommuting are highly paid.

Suppose that the structural IT adoption equation takes the form

(2) $$T_i = T(y_i, X_i, Z_i, C_i)$$

where y_i, X_i, and T_i are defined as before, Z_i are factors that affect the relative costs of telecommuting,[3] and C_i is the expected daily commuting length in the local labor market. If IT technology adoption is influenced by labor market earnings, $\frac{\partial T_i}{\partial y_i} \neq 0$ which in turn implies that $Cov(T_i, u_i) \neq 0$. Consequently, the least squares estimate of γ_2 will be $\gamma_2 + \frac{Cov(T_i, u_i)}{Var(T_i)}$. The direction of bias is not known in general, but if IT technologies are normal goods, $\frac{\partial T_i}{\partial y_i} > 0$ and $Cov(T_i, u_i) > 0$. In that case, least squares estimates of γ_2 will be biased upward.

The reduced form of the IT adoption equation can provide the instruments needed to identify the technology adoption effect on earnings in (1). The empirical approximation to the reduced form of the IT adoption decision is

(3) $T_i^* = X_i\theta_x + Z_i\theta_Z + C_i\theta_C + v_i$,

where we observe $T_i = 1$ when the latent variable T_i^* >0 and $T_i = 0$ otherwise. Because elements of Z_i and C_i affect the decision of whether to select a job that allows telecommuting but do not directly affect the compensation offered by firms, we can use Z_i and C_i as instruments for T_i in (1).

Estimates of the technology adoption equation (3) are arguably more interesting than the earnings function estimation. Take the case of telecommuting. The choice depends positively on the average length of a physical commute because telecommuting from home is a substitute for working at the plant. The longer the physical commute, the greater the utility from saved

---

[3] These can involve both pecuniary and nonpecuniary costs associated with choice of work location. For example, slow internet connections such as dial-up services are less expensive but are more difficult to use than are high-speed connections, and so the latter are more convenient. Individuals may also differ in their attitudes toward telecommuting, some preferring physical proximity to coworkers.

time and opportunity cost from telecommuting. Similarly, better infrastructure supporting telecommuting, an element of Z_i, lowers the cost of technology adoption from home and increases the likelihood of telecommuting.[4] As we show below, rural residents face shorter commutes and poorer IT infrastructure, both of which will lower rural adoption rates relative to urban adoption rates. Estimation of (3) will allow us to assess the roles of these variables in explaining the urban-rural digital divide relative to the importance of other differences between urban and rural areas such as differences in education. We will also be able to show whether equalizing broadband access will equalize IT use between urban and rural markets.

The dichotomous variable T_i takes the value of 1 if the individual chooses the job in which telecommuting is an option.[5] An individual will choose the job allowing telecommuting if the indirect utility from that job dominates the best alternative job that does not allow telecommuting. A job offering no telecommuting offers indirect utility of $U_0 = U_0(X_i, \alpha_Z Z_i, y_{0i}, C_i, T_i = 0)$. The individual does not absorb work-related costs of telecommuting ($\alpha_Z = 0$). On the other hand, the individual faces the full cost of commuting of C_i per day, and so y_{0i} must be sufficiently high to compensate for the disutility of commuting. An otherwise identical job with a telecommuting option has a lower expected physical commuting time $\alpha_C C_i$, $0 < \alpha_C < 1$, but the worker has to absorb the full telecommuting costs, Z_i.[6]

---

[4] Mokhtarian and Salomon (1996) examine the role of specific firm policies as well as technological constraints in affecting the probability of telecommuting. Our focus is solely on technological constraints; in particular, access to high-speed Internet. Implicit in our focus is that both the firm and the worker react to the technological environment in deciding what job attributes to offer and to accept, and that workers can move to other firms if they are not satisfied with the job attributes at their current firm. Consequently, specific firm policies regarding telecommuting are endogenous and cannot be used to 'explain' telecommuting.

[5] We present the choice as two different jobs, but this could be the same job with and without telecommuting. Individuals may opt not to telecommute if the disutility from telecommuting (distractions, isolation, poor infrastructure) outweighs the positives.

[6] If the individual works 100% of the time from home, then $\alpha C_i = 0$. However, those workers are invariably self-employed. Most telecommuters will have to physically commute at least occasionally, if only because firms need to monitor their effort, but also because telecommuting and face-to-face interactions may be complements (Autor (2001)).

The indirect utility from the job changes to $U_1 = U_1(X_i, Z_i, y_{1i}, \alpha_C C_i, T_i = 1)$. If $U_1 > U_0$, the individual takes the telecommuting option. Note that adding the telecommuting option cannot make the worker worse off because the worker can always retain the old job. Those who do select the telecommuting option must be better off.

Telecommuting could raise or lower worker pay. Telecommuting could raise worker marginal product, allowing the firm to pay a higher wage. Or, telecommuting may attract more productive workers who are paid higher wages. Alternatively, telecommuting could lower pay if a sufficient number of workers view access to telecommuting as a positive job attribute and are willing to accept lower compensation in return.

Our measure of physical commuting time, $\mathrm{C_i}$, is the average commuting time in the home county. We cannot use the actual commute time to the job, $\alpha_C \mathrm{C_i}$, because that is chosen jointly with the decisions to telecommute and to accept the earnings offered by the firm. We use the average commute time in the county because it will not vary with the actual job selected. We assume that higher average commute time implies higher average commutes for jobs with and without telecommuting.

We include two elements in Z_i. The first is the average number of high-speed Internet providers in the county. As the number of providers increases, competition among providers should cause the cost of home access to decline. Broadband access is particularly useful for telecommuting because cable modem lines and DSL are at least five times faster than typical telephone modem lines and so high-speed Internet improves the productivity of computer use from home. A second element of Z_i is the individual's attitude toward technology. Specifically, this measure of Z_i is a dummy variable indicating whether the individual answered positively to the question, "Overall, do you think that new technologies such as the Internet, cell phones, and pagers have made the world better place?" Individuals answering positively are presumed to be less averse to the complications of setting up a computer workspace at home. We expect that individuals who view information technology more favorably will be less averse to the inconvenience of setting up a home office with the computer or Internet links needed for work.[7]

We estimate equation (3) using probit. Elements of Z_i and C_i will alter the probability of selecting a telecommuting job but will not directly affect earnings. Consequently, the predicted probability of telecommuting can be used in place of T_i in equation (1) in order to derive unbiased estimates of γ_2. Because this two-step estimation procedure is inefficient, we bootstrap the standard errors.

If individuals move because of local broadband access, our instrument may be subject to choice. Our use of county average access rather than individual access or use of broadband for telecommuting is predicated on the assumption that moves become more expensive with distance. Individuals might move across zip codes within a county in order to get high-speed Internet access at the home, but are less likely to move across counties for that purpose because of the greater cost of the longer move.[8] In addition, the rapid deployment of broadband across the county would suggest that most households in unserved neighborhoods would have some expectation that they would get service in a short time. In fact, 93% of the zip codes in the sample had at least one provider by 2001. Later, we find that these elements of Z_i and C_i pass the overidentification tests for their inclusion as instruments for T_i in (1).[9]

---

[7] Measures of this type were used by Mokhtarian and Solomon (1996) and Liu et al (2004). As shown below, they turn out to have no impact on technology adoption, nor do attitudes toward technology differ between or urban and rural workers.

[8] One could also explain that we are using the labor market average Z_i rather than the actual costs absorbed by the worker ($\alpha_Z Z_i$), $0 \le \alpha_Z \le 1$ because $\alpha_Z Z_i$ is jointly selected with y_i.

[9] None of our results are sensitive to successive exclusion of each instrument.

Nevertheless, it is possible that if individual unobserved ability is correlated with market-wide averages that influenced the probability of local broadband deployment, our results could still be clouded by unobserved heterogeneity in individual ability that is correlated with broadband access. We employ two robustness checks to examine the sensitivity of our results to this possible source of bias. First, we estimate the model using the subset of metropolitan observations where the variation in broadband access is only in the number of providers and not whether or not access was available. In those markets, differential competitive environments may alter the cost of broadband access, but virtually everyone would have access to at least one provider.

A second is to control for the probability that the local area would have a high-speed internet provider. Rather than model the probability explicitly, we posit that Internet firm entry decisions into a particular county market would be based on easily observed local market factors such as average earnings, education, employment levels, and population density. Following Röller and Waverman (2001), we also include measures of county public debt per capita and state telephone receipts per household. Using L as the vector of these local indicators of potential demand for internet service, let the probability of service be given by the function $h(L)$. Inserting $h(L)$ or its arguments as nuisance parameters into equations (1) and (3) is a correction for the potential selection on observables problem.[10]

$$\begin{aligned} y_i &= X_i\gamma_1' + T_i\gamma_T' + h(L)\lambda_y + u_i' \\ T_i^* &= X_i\theta_X' + Z_i\theta_Z' + C_i\theta_C' + h(L)\lambda_T + v_i' \end{aligned} \tag{4}$$

If there were a serious problem with correlation between the errors in (1) or (3) and local factors that would alter the probability of local high-speed Internet access, it should result in

[10] See Barnow, Cain and Goldberg (1981).

sharp differences in the parameters estimated with specifications (1) and (3) compared to those in (4).

III. Data

The primary source of data for this study is the 2001 UCLA Internet Survey conducted by the Center for Communication Policy (CCP) at UCLA. This is a nationally representative survey of computer and Internet use that also included information on location of use, employment status, earnings, and demographic information. The survey also included residential zip code, but that was not universally reported. We use the employed subsample for which we had zip code and earnings information. Sample statistics for the variables used in this study are reported in Table 1. The working data set includes 924 observations on individuals between ages 23 and 65. Of these, 624 reported their income. Younger and older respondents are excluded to avoid complications caused by computer adoption and commuting decisions that would interact with nonjob-related decisions such as education or retirement. All statistics are calculated using the weights provided by CCP.

Income was reported by ranges, so we use the midpoint of each range. Average income was $33,224, somewhat lower than the contemporaneous average of $36,219 in the Current Population Survey. The other endogenous variables are various indicators of computer or Internet use at work and at home. Forty-seven percent used a computer at work and 27% used the Internet at work. In contrast, 13% used a computer for work from home and 11% used the Internet for work from home. These last two are our indicators for telecommuting. Note that to telecommute in our application, it is not necessary to be logged in to the firm's system. In fact, one need not use the Internet at all in order to telecommute, although most do. For our purposes, telecommuting is using information technology from home for work purposes. As an added measure, we also have information on any use of the Internet, whether at work or at home and whether for work or for personal use. Seventy-three percent reported having used the Internet under that definition.

Our measures of X_i include gender, marital status, age, potential work experience (age minus education minus six), education, racial or ethnic status, and rural residence. We will discuss this last measure in more detail below. The other variables are self-explanatory.

As discussed earlier, we use county averages of commuting time and High-Speed Internet access as measures of C_i and Z_i. County averages will more closely represent the expected costs of commuting and telecommuting as opposed to representing the actual choice made by the individual. Average commuting time by county is available from the U.S. Census (2000). The Federal Communications Commission (FCC) provides information on the number of high-speed (cable or DSL) providers by zip code.[11] We aggregated this data to the county level, so our high-speed access measure is the average number of high-speed Internet providers per zip code in the county.[12] Our other measure of $Z_{i,}$ the dummy variable indicating individual attitudes toward IT technology, is available directly from the UCLA survey.

The Urban-Rural Gap in Access and Utilization

One of the concerns with the rapid expansion of high-speed Internet was that rural residents would be left behind as firms entered more lucrative urban markets. In fact, there are only modest differences in Internet usage between urban and rural markets, suggesting that the concerns may have been overblown. There are two reasons the Internet usage data can be

[11] The data also includes satellite providers which allow high-speed down link service but only slow phone uplink. However, only a 1.7% of the customers in December 2001 in the Local Telephone Competition and Broadband Deployment data base had satellite service (FCC, 2002). Data can be downloaded at http://www.fcc.gov/wcb/iatd/comp.html

[12] We obtained similar results when we used the actual number of high speed Internet providers in the zip code of residence.

misleading. First, high-speed Internet access does differ between rural and urban markets, and so the similarities in overall Internet rates may mask differences in high-speed Internet use. It is the latter that is most likely to be used in business applications. Second, most studies do not actually have data on urban-rural differences, but rather on metro-nonmetro differences. The latter data are dominated by suburban populations that may overstate Internet access in rural areas.

We illustrate average broadband access by degree of urbanization in Figure 1. We use "Beale" codes to indicate population density. Values range from 0-9 with higher values signifying a progression from most metropolitan to most rural. There is a clear distinction in access. Counties with Beale codes 6-7 (under 20,000 urban population) average fewer than 3 providers per zip code with about 85% having at least one. Counties characterized as 8-9 (under 2,500 urban population) have fewer than 2 providers per zip code with 70% having at least one. In contrast, counties in the 0-5 range (metropolitan or large urban) have over 3 providers per zip code and over 90% have at least one provider.[13]

The sample statistics in Table 1 are broken down by urban and rural residence.[14] Rural workers earn less on average. They also have lower levels of technology use both at home and at work. The biggest differences are in telecommuting. Urban workers are nearly twice as likely to telecommute, whether by using the Internet or a computer for work at home. Urban workers are 43% more likely to use the Internet from work. The proportional gap in Internet use for any purpose is only 10%, much smaller than the work-related use of the Internet. Unclear is whether

[13] Our numbers bias upward the number of providers somewhat because the FCC does not report the actual number of providers when there are 1-3 but only that there are between 1 and 3 providers. We characterize zip codes in this category as having 2 providers, but national averages suggest that more will have only 1 than 2 or 3. It is probable that the upward bias is greatest for the smallest counties.

[14] We treat counties with Beale codes 6-9 as rural. Our conclusions were not changed when we treat the larger 6-7 counties differently from the smaller 8-9 counties.

these differences in telecommuting or work-related Internet use are due to unequal access to service or if they are due to unequal demand for those services between the urban and rural markets.

There are clear differences between the two groups that would have the potential to affect decisions to telecommute. Rural workers have moderately lower levels of education. Rural areas also have less access high-speed Internet access at the home. On the other hand, rural areas are less likely to be populated by racial or ethnic groups that have had lower adoption rates nationally. In addition, average commuting time is actually higher in the urban areas. Therefore, if telecommuting represents a means to conserve on commuting time, it may provide more advantages to urban than to rural workers. Interestingly, there is no variation in the IT tastes between urban and rural workers. Consequently, the gap in telecommuting is not driven by differences in attitudes toward technology between urban and rural markets.

IV. Computer and Internet Adoption

Table 2 reports the results of probit equations estimated for each of the five measures of individual IT adoption: use of a computer and use of Internet from home for work; use of a computer or the Internet at work; and the use of the Internet anywhere for any purpose including recreation. Only the first two are considered telecommuting. Use of the same technologies at work provides a frame of reference for the home technology adoption decision, and the last measure provides a frame of reference for alternative uses of IT technologies.

The demographic measures perform as in earlier studies. Blacks and Hispanics are less likely to engage in all five forms of information technology use while the more educated are significantly more likely to use all technologies. Men and women are equally likely to use IT for work purposes, but men are more likely to use the Internet overall.

Married individuals are significantly more likely to telecommute but the significance disappears in terms of computer and Internet use at work. This suggests that telecommuting may be complementary with household production activities related to child care. The survey was not sufficiently detailed to assess that possibility directly.

The probability of telecommuting peaks at 18-19 years of work experience or about 38 years of age at sample means. In contrast, the use of these technologies peaks at slightly younger ages at work. Interestingly, the use of the Internet for all purposes declines with age throughout, so the youngest are the most likely to adopt the technology overall. The contrast with the age profiles for the use of these technologies for work purposes suggests that the young use the Internet more intensively as a recreational service.

Our instruments have impacts on adoption that would seem quite reasonable. Individuals in counties with higher average commutes are significantly more likely to work from home, using computers with or without the Internet. The marginal effects are much smaller and insignificant in adopting these same technologies at work, as there should be no particular benefit or cost relating travel time to work with the technologies used at work. Finally, commuting time does not significantly affect Internet use for all purposes. The contrast to the first column's result is presumably due to the fact that commuting time should not affect recreational uses of the Internet.[15]

High speed Internet access significantly affects only home use of Internet technologies. The peak for use occurs at about .7 providers, suggesting that what is most important for telecommuting is the presence of at least one provider and not the presence of several providers

[15] The joint test of the significance of the instruments on technology adoption passes in all cases of IT use from home but fail in the IT use at work. The instruments are much weaker in explaining IT use at work. Our primary interest is in the role of IT adoption from home, but we include the results on IT adoption at work for completeness. However, the earnings function estimates for IT adoption at work should be interpreted cautiously.

from which to choose. The coefficients on access are similar for the use of computers from home and for the use of the Internet from work but are not significant. Access has virtually no impact on computer use at work. It seems apparent that broadband access is particularly important for telecommuting as opposed to other forms of IT adoption.

Two other variables never significantly affect either computer or Internet adoption. The first is the individual's attitudes toward information technologies, and so the belief that "technophobia" leads to a digital divide is not supported in this sample of workers. Second, adoption is not significantly different between rural areas and urban areas after controlling for the factors included in the model, and so the model can fully explain the rural-urban differences in mean adoption rates that we found in Table 1.

Table 3 reports the Blinder-Oaxacca decomposition of the rural-urban differences in technology adoption to identify which factors are most important in explaining why rural adoption lags. The original Blinder-Oaxaca decompositions assumes a linear regression model. Since the probit model is nonlinear, it cannot be decomposed exactly. Some studies use the coefficient estimates from a linear probability model (LPM) to approximate the decomposition as in Fairlie (2004).[16] The potential problem is that the linear probability model is sensitive to outliers. Our strategy used the estimated index values from the probit model to allocate each explanatory variables share of the predicted difference in technology adoption between urban and rural areas. Denote the parameters from the probit model as δ and let $\bar{W}^u$ and $\bar{W}^r$ be the vector of urban and rural average values. The kth elements of these vectors are denoted by $\bar{w}_k^u$ and $\bar{w}_k^r$, respectively. The total explained difference between urban and rural technology

[16]As it turned out, the decomposition based on the linear probability model is nearly identical. To the results reported in Table 3.

use is $D_{IT} = F(\bar{W}^u \delta) - F(\bar{W}^r \delta)$ where F is the normal distribution function. We calculate the kth variable's share of this gap by

$$(5) \qquad s_k = \frac{(\bar{w}_k^u - \bar{w}_k^r)\,\delta_k}{(\bar{W}^u - \bar{W}^r)\,\delta},$$

where δ_k is the associated probit coefficient attached to the kth factor. By multiplying D_{IT} by s_k, we can estimate the explained urban-rural difference in IT adoption attributable to the kth factor.

Four factors stand out. First, the low levels of Blacks and Hispanics in rural areas actually would tend to raise adoption rates there. However, lower education levels in rural areas more than counteracts the minority effect. Higher average travel time to work in urban areas also explains about 10% of the difference in telecommuting but not other forms of IT adoption. However, by far the most important factor leading to differences in IT adoption are differences in broadband access. Three-fourths or more of the difference in adoption rates between urban and rural areas can be attributable to differences in the average number of providers by zip code.[17] Clearly, broadband access matters for Internet and computer adoption and will have an impact on telecommuting. As the gap in broadband access between rural and urban markets continues to decrease, the urban-rural gap in telecommuting should diminish.

We estimated the models used in Table 2 separately for the urban and rural samples. The possibility that nonrandom placement of high-speed Internet services might be correlated with unobserved individual heterogeneity should be most severe in the rural counties, leading to greater bias in the rural estimates than the urban estimates. However, a joint test of the equality of the coefficients between the urban and rural areas found that the null hypothesis of equality could never be rejected at standard significance levels. The only individual coefficients that

[17] The qualitative results in Tables 2 and 3 were unchanged when we reestimated the equations using the proportion of zip codes with at least one provider as the measure of broad band access.

differed significantly in some specifications were those on marital status and education, although the signs were the same. The key instrumental variables had statistically similar effects in urban and rural samples, suggesting that the rural coefficients were not biased by the lower probability of broadband deployment in rural markets.

The first two columns of Table 4 report the results for the two telecommuting equations, our primary interest.[18] When we add the elements of *L* into the probit telecommuting equation, none of the substantive results change. The coefficient on the rural dummy changes from insignificant and negative to insignificant and positive, but no other parameters from Table 2 change sign or magnitude, although marginal significance levels decrease modestly. In fact, we cannot reject the joint hypothesis that the vector of coefficients, $\lambda_T = [0]$, so that local factors that should influence the likelihood of local provision of broadband service do not affect individual decisions of whether to telecommute. Our results do not appear to be driven by underlying correlation between unobservable individual attributes and factors influencing where broadband services were deployed.

V. Returns to Telecommuting and IT Use at Work

To determine whether the differential IT adoption rates lead to income differentials between urban and rural areas, we estimate equation (1). Each measure of computer or Internet use was inserted separately into the model. As is standard, labor earnings are transformed into log form. We first treat the various measures of computer and Internet adoption as exogenous. We then use the results of Table 2 to generate unbiased measures of the returns to these IT adoptions.

[18] We lose some observations because of missing county level data for some of the observations. Note that all of the elements of *L* predate 1998, the first year that the FCC reports that broadband was made available for home use. In that way, none of the elements of *L* should reflect reverse influence from home broadband deployment.

The first set of estimates that treat the various IT uses as exogenous is reported in Table 5. The standard elements of the log earnings function behave typically. There are positive returns to education of about 8% per year. Returns to potential experience are positive and concave, but peak at an unrealistically low level of about 3 years. Males, married workers and those residing in urban areas are paid more. [19] Minorities are paid less but the coefficient is never significant.

For our primary interest, returns to computer and Internet use are substantial and highly significant. They are highest for the use of the Internet from home. Returns to any Internet use including recreational uses are much smaller and statistically insignificant. The literal interpretation is that work-related adoption of IT technologies has a large effect on earnings, implying that the differences in broadband accessibility between urban and rural areas will exacerbate the income gap between urban and rural areas. However, the implied returns of over 40% are unreasonably high, suggesting that the returns allocated to telecommuting or working with computers or the Internet at work are due instead to unmeasured individual attributes that are correlated with telecommuting or IT use.

Table 6 reports the earnings function estimates controlling for the presumed endogeneity of computer and Internet use.[20] The demographic variables perform similarly to the coefficient estimates in Table 5 with one exception. The experience profiles in Table 6 are much more reasonable, peaking at about 26 years rather than 3, suggesting that the endogenous technology adoption decision is particularly correlated with work experience. The rest of the parameters are

[19] The male effect is unusually large. However, we have annual earnings rather than hourly wages. Part of the unusually large male earnings advantage is their higher average hours worked per year and lower probability of working part-time.

[20] The Chi Square test of the overidentification restrictions failed to reject the null hypothesis at the 0.10 significance level in every specification, supporting the use of these instruments. Specifications using various subsets of these instruments yielded similar outcomes.

similar in magnitude and significance except that the marital premium found in Table 5 loses significance.

To our main concern, after controlling for endogeneity, returns to computer and Internet adoption become smaller in magnitude and are no longer statistically significant, consistent with the presumption that $Cov(T_i, u_i) > 0$. Individuals with higher unexplained labor earnings are more likely to use information technologies for work purposes. Estimated returns to "at-the-job" use of these technologies fell the most in magnitude and significance after controlling for endogeneity. Estimated returns to telecommuting, either by working from home on a computer or by Internet remain large at 41% but have standard errors of like magnitudes. The implication is that there are no additional returns to telecommuting beyond the conveniences it offers to workers. While urban workers have an advantage in broadband access and opportunities to work from home, those opportunities will not broaden the urban-rural earnings gap.

We replicated the analysis inserting the vector of local factors that should shift the probability of high-speed Internet provision as in the second equation in (4). None of the conclusions change, as shown in the last two columns of Table 4, although the local factors are jointly significant. Most important for our purposes, estimated returns to instrumented IT adoption remain insignificant.

It is important to note that while individuals do not earn more because they telecommute, the opportunity to telecommute may still have an impact on average rural earnings. If the opportunity to telecommute broadens the geographic boundaries of labor markets, high-skilled and highly paid workers may move to rural areas that have broadband access. While those individuals will not be paid more than they would in the urban market, they will earn more than the average rural resident. Consequently, improving rural broadband access may yet serve to reduce the urban-rural wage gap.

VI. Conclusions and Extensions

Evidence suggests that broadband access has a large impact on the incentives to work from home using the computers and the Internet. These differences in access explain three-quarters of the gap in the probability of telecommuting between urban and rural labor markets. Incentives to telecommute also increase in response to average commuting time, but the average commute is actually higher in urban than in rural markets. Nevertheless, the large impact of broadband access on the urban-rural gap in telecommuting suggests that as broadband access continues to improve in rural areas, the gap in telecommuting will also greatly diminish.

Telecommuting does not raise individual earnings significantly, at least not as of 2001. It is conceivable that further expansion of broadband access to rural markets can shrink the urban-rural wage gap by allowing highly paid workers to move to more remote areas, just as improvements in information technologies have allowed the separation of headquarters from production activities and the migration of headquarters to smaller cities (Klier and Testa, 2002, Strauss-Kahn and Vives, 2004). We could not explore the possibility that broadband access is allowing skilled workers to move farther from work in our single cross-section. The only way to address that hypothesis directly would be to have longitudinal data on workers with a sample large enough to capture a sufficient number of cross-county moves. Alternatively, one could look at the relative growth of skilled labor in urban and rural markets as broadband access becomes more universal.

References

Acemoglu, Daron. 2002. “Technological Change, Inequality, and Labor Market,” *Journal of Economic Literature* 40 (1): 7-72.

Autor, David H. 2001. “Wiring the Labor Market.” *Journal of Economic Perspectives* 15 (1): 25-40.

Autor, David H., Katz, Lawrence F., and Alan B. Krueger. 1998 “Computing Inequality: Have Computers Changed the Labor Market?” *Quarterly Journal of Economics*. 113 (4): 1169-1213.

Barnow, Burt S., Glen G. Cain and Arthur Goldberger. 1981. “Selection on Observables.” *Evaluation Studies Review Annual* 5: 43-59.

Blinder, Alan S., “The Internet and the New Economy,” *The Internet Policy Institute*, policy brief #60, Available: http://www.brookings.edu/comm/policybriefs/pb60.htm

DiNardo, John E., and Jorn-Steffen Pischke. 1997. “The Returns to Computer Use Revisited: Have Pencils Changed the Wage Structure Too?” *Quarterly Journal of Economics* 112(1): 291-303.

Dunne, Timothy, Lucia Foster, John Haltiwanger and Kenneth R. Troske. 2004. “Wage and Productivity Dispersion in United States Manufacturing: The Role of Computer Investment.” *Journal of Labor Economics* 22 (2): 397-430.

Entorf, Horst; Michel Gollac and Francis Kramarz. 1999. “New Technologies, Wages, and Worker Selection.” *Journal of LaborEconomics* 17: 464-491.

Fairlie, Robert W. 2004. “Race and The Digital Divide,” *Contributions to Economic Analysis & Policy*, 3 (1):1-38.

Gabe, Todd M. and Jaison R. Abel. 2002. “Deployment of Advanced Telecommunications Infrastructure in Rural America: Measuring the Digital Divide,” *American Journal of Agricultural Economics* 84 (5):1246-1252.

Hausman, Jerry. 2002. “Internet related services: The results of asymmetric regulation” in R.W. Crandall and J. H. Alleman, eds. *Broadband: Should we regulate High-Speed Internet access?* Washington,DC: AEI-Brookings Joint Center for Regulatory Studies.

Jorgensen, Dale W. 2001. “Information Technology and the U.S. Economy,” *American Economic Review* 91 (1): 1-32.

Klier, Thomas, and William Testa. 2002. “Location trends of large company headquarters during the 1990s” *Economic Perspectives*, Federal Reserve Bank of Chicago 20: 12-26.

Krashinshy, Harry A.2004. “Do Marital Status and Computer Usage Really Change the Wage Structure?” *Journal of Human Resources* 39(3): 774-791.

Krueger, Alan B. 1993, “How Computers Have Changed the Wage Structure: Evidence from Microdata, 1984-1989.” *Quarterly Journal of Economics* 108 (1): 33-60.

Lee, Sang-Hyup, and Jonghyuk Kim. 2004. “Has the Internet Changed the Wage Structure too?” *Labour Economics* 11: 119-127.

Litan, Robert E., and Alice M. Rivlin. 2001. “Projecting the Economic Impact of the Internet,” *American Economic Review* 91 (2): 313-317.

Liu, Jin-Tan, Tsou, Meng-Wen, and James K. Hammitt. 2004. “Computer Use and Wages: Evidence from Taiwan,” *Economics Letters* 82: 43-51.

Mokhtarian, Patrica, L., and Ilan Salomon. 1996. “Modeling the Choice of Telecommuting 3: Identifying the Choice Set and Estimating Binary Choice Models For Technology-Based Alternatives,” *Environment and Planning A* 28:1877-1894.

Mokhtarian, Patrica, L., Salomon, Ilan, and Sangho Choo, 2005. "Measuring the Measurable: Why Can't We Agree on the Number of Telecommuters in the U.S.?," *Quality and Quantity* 35: 423-452.

Moretti, Enrico. 2004. “Workers’ Education, Spillovers, and Productivity: Evidence from Plant-level Production Functions.” *American Economic Review* 94 (3): 656-690.

National Telecommunications and Information Administration. 2000. “Falling Through the Net: Toward Digital Inclusion: A Report on American’s Access to Technology Tools,” http://www.ntia.doc.gov/ntiahome/fttn00/Falling.htm#2.

Oaxaca, Ronald 1973. “Male-Female Wage Differentials in Urban Labor Markets” *International Economic Review* 14: 693-709.

Oliner, Stephen D., and Daniel E. Sichel 2000. “The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?” *Journal of Economic Perspectives* 4(4): 3-22.

Prieger, James E.2003. “The Supply Side of the Digital Divide: Is There Equal Availability in the Broadband Internet Access Market?” *Economic Inquiry* 41 (2): 346-3

Röller, Lars-Hendrick and Leonard Waverman. 2001. “Telecommunications Infrastructure and Economic Development : A Simultaneous Approach.” *American Economic Review* 91 (4):909-923.

Strauss-Kahn, Vanessa and Xavier Vives. 2005. “Why and Where do Headquarters Move?” CEPR Discussion Paper #5070, May.

U.S. Federal Communications Commission. 2002. “High-Speed Services for Internet Access: Status as of December 31, 2001.” (July) http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/hspd0702.pdf

Table 1. Descriptive statistics

Variables	Total		Urban		Rural	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
Endogenous						
Internet for Job Home	0.12	(0.01)	0.13	(0.01)	0.07	(0.02)
Computer for Job Home	0.14	(0.01)	0.15	(0.01)	0.08	(0.02)
Internet at Work	0.29	(0.01)	0.30	(0.02)	0.21	(0.03)
Computer at Work	0.46	(0.02)	0.47	(0.02)	0.41	(0.04)
Any Internet Use	0.76	(0.01)	0.78	(0.02)	0.71	(0.04)
Labor Income	33160	(1002)	34741	(1190)	26366	(1315)
Exogenous						
Male	0.48	(0.02)	0.48	(0.02)	0.49	(0.04)
Married	0.60	(0.02)	0.59	(0.02)	0.64	(0.04)
Age	43.49	(0.38)	43.55	(0.42)	43.23	(0.94)
Experience	24.00	(0.39)	23.99	(0.43)	24.07	(0.93)
Education	13.49	(0.07)	13.56	(0.08)	13.16	(0.16)
White	0.72	(0.01)	0.70	(0.02)	0.82	(0.03)
Black	0.14	(0.01)	0.15	(0.01)	0.09	(0.02)
Asian	0.03	(0.01)	0.04	(0.01)	0.02	(0.01)
Native Am.	0.03	(0.01)	0.03	(0.01)	0.02	(0.01)
Minority	0.23	(0.01)	0.25	(0.02)	0.13	(0.03)
Instruments						
Travel Time	23.97	(0.15)	24.12	(0.16)	23.28	(0.43)
Technology Interest	0.34	(0.02)	0.34	(0.02)	0.34	(0.04)
Avg. Broadband Providers (county)	5.29	(0.10)	5.95	(0.11)	2.19	(0.11)

There are 924 observations on working individuals in the complete data set, of which 762 are urban and 162 are rural.
Of these, 647 reported their income, 521 urban and 126 rural.

Table 2. Probit Estimation Results on Each Dependent Variable

	IJH		CJH		IW		CW		AI	
Variables	dF/dx	Std. Err.	dF/dx	Std. Err.	dF/dx	Std. Err.	dF/dx	Std. Err.	dF/dx	Std. Err.
Minority	-0.036	(0.019)	-0.051	(0.022)	-0.123	(0.042)	-0.138	(0.054)	-0.090	(0.048)
Married	0.039	(0.016)	0.056	(0.019)	0.049	(0.034)	0.023	(0.041)	0.072	(0.031)
Male	0.024	(0.017)	0.022	(0.019)	0.056	(0.033)	-0.050	(0.039)	0.054	(0.028)
Education	0.029	(0.004)	0.036	(0.004)	0.073	(0.007)	0.079	(0.009)	0.065	(0.009)
Experience/10	0.101	(0.030)	0.113	(0.036)	0.086	(0.060)	0.255	(0.071)	-0.133	(0.055)
(Experience/10)2	-0.028	(0.006)	-0.030	(0.008)	-0.031	(0.012)	-0.070	(0.014)	0.012	(0.010)
Rural Area	-0.015	(0.023)	-0.021	(0.026)	-0.035	(0.050)	-0.064	(0.058)	-0.053	(0.049)
Instruments										
Technology Interest	0.018	(0.019)	0.010	(0.021)	-0.033	(0.035)	0.006	(0.042)	0.014	(0.031)
Travel Time/100	0.346	(0.170)	0.525	(0.200)	0.289	(0.370)	0.101	(0.443)	0.372	(0.337)
ABP/10	0.172	(0.100)	0.200	(0.116)	0.192	(0.208)	-0.077	(0.251)	0.341	(0.183)
$(ABP/10)^2$	-0.125	(0.077)	-0.142	(0.093)	-0.107	(0.158)	0.032	(0.197)	-0.307	(0.145)
Pseudo R2	0.232		0.233		0.176		0.142		0.186	
N	924		924		924		924		924	

Note: IJH: use of the Internet for job at home; CJH: use of a computer for job at home; IW: Use of the Internet at work; CW: use of a computer at work; IA: use of the Internet for any purposes. ABP is the average number of broadband providers per zip code in the county.

Table 3. Blinder-Oaxaca Decomposition

	IJH	CJH	IW	CW	IA
Minority	-13.00%	-15.82%	-34.61%	83.88%	-19.79%
Married	1.15%	1.40%	1.14%	-1.19%	1.45%
Male	1.62%	1.24%	3.04%	6.22%	2.70%
Education	19.22%	20.39%	39.97%	-99.39%	32.70%
Experience	-2.16%	-1.92%	-3.45%	10.30%	-3.98%
Technology Interest	5.11%	2.60%	-8.09%	-3.35%	3.10%
Travel Time	8.71%	11.35%	5.96%	-4.79%	6.99%
ABP	79.35%	80.76%	96.05%	108.32%	76.83%

Note: IJH: use of the Internet for job at home; CJH: use of a computer for job at home; IW: use of the Internet at work; CW: use of a computer at work; IA: use of the Internet for any purposes. ABP is the average number of broadband providers per zip code in the county.

Table 4. Replication of Technology Adoption and Log Earnings Equations for Home Use of IT Technology Using Equation (4)

	IJH		CJH		log earnings		log earnings	
Variables	dF/dx	Std. Err.	dF/dx	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
IJH[a]					0.379	(0.322)		
CJH[a]							0.352	(0.311)
Minority	-0.031	(0.018)	-0.045	(0.021)	-0.046	(0.068)	-0.044	(0.068)
Married	0.037	(0.014)	0.052	(0.018)	0.140	(0.070)	0.139	(0.071)
Male	0.022	(0.015)	0.020	(0.018)	0.462	(0.052)	0.465	(0.052)
Education	0.026	(0.004)	0.033	(0.004)	0.088	(0.019)	0.087	(0.02)
Experience/10	0.102	(0.028)	0.119	(0.034)	0.223	(0.089)	0.219	(0.090)
(Experience/10)2	-0.028	(0.006)	-0.032	(0.008)	-0.041	(0.052)	-0.040	(0.019)
Rural Area	0.031	(0.035)	0.02	(0.038)	-0.192	(0.083)	-0.192	(0.083)
Instruments								
Technology Interest	0.020	(0.018)	0.013	(0.020)				
Travel Time/100	0.290	(0.222)	0.633	(0.272)				
ABP/10	0.103	(0.094)	0.124	(0.116)				
$(ABP/10)^2$	-0.101	(0.070)	-0.113	(0.088)				
X^2 (9) test of joint significance of vector *L*	12.2		10.1					
F(9, 615) test of joint significance of vector *L*					2.98		3.12	
Pseudo R2	0.254		0.250		0.335		0.335	
N	902		902		633		633	

All regressions include variables that are believed to affect the number of high-speed Internet providers in the county by 2000 including log county average 1997 earnings per job; log growth in nonfarm employment between 1994 and 1997; percent of 1990 county population aged 25 and over with a highschool degree; percent with an associates degree; percent with at least a BA degree; log 1997 public county debt per capita; log 1990 county population density; log 1990 county population; and log 1997 telephone revenues per household in the state. All variables are selected to predate the first deployment of broadband to individual homes which began in 1998.
Critical value of the X^2 (9) test at the .10 level is 14.7. Critical value of F(9, 615) at the .10 level is 1.70.
[a] Instrumented

Table 5. Log-earnings Function Estimation Results: OLS

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Dependent variables										
IJH	0.533	(0.064)								
CJH			0.448	(0.070)						
IW					0.450	(0.056)				
CW							0.475	(0.051)		
IA									0.129	(0.073)
Independent variables										
Minority	-0.070	(0.065)	-0.071	(0.066)	-0.041	(0.068)	-0.037	(0.066)	-0.071	(0.069)
Married	0.120	(0.065)	0.113	(0.065)	0.106	(0.065)	0.092	(0.061)	0.127	(0.066)
Male	0.456	(0.050)	0.461	(0.050)	0.442	(0.051)	0.475	(0.050)	0.457	(0.052)
Rural Background	-0.138	(0.052)	-0.139	(0.052)	-0.143	(0.049)	-0.162	(0.049)	-0.155	(0.052)
Education	0.083	(0.011)	0.084	(0.011)	0.077	(0.011)	0.079	(0.010)	0.104	(0.011)
Experience/10	2.263	(0.826)	2.268	(0.820)	2.649	(0.783)	1.820	(0.786)	2.870	(0.815)
(Experience/10)2	-4.187	(1.719)	-4.193	(1.703)	-4.692	(1.645)	-2.740	(1.642)	-5.422	(1.689)
Constant	8.496	(0.163)	8.483	(0.163)	8.458	(0.164)	8.400	(0.157)	8.115	(0.158)
R2	0.361		0.349		0.379		0.406		0.311	
N	647		647		647		647		647	

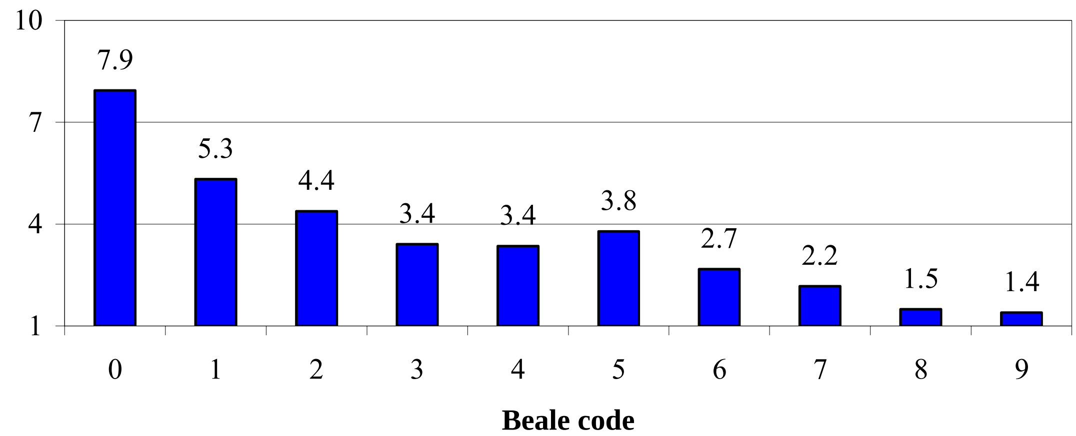
Note: IJH: use of the Internet for job at home; CJH: use of a computer for job at home; IW: use of the Internet at work; CW: use of a computer at work; IA: use of the Internet for any purposes.

Table 6. Log-earnings Function Estimation Results: IV

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Dependent variables										
IJH	0.418	(0.376)								
CJH			0.408	(0.354)						
IW					0.129	(0.524)				
CW							-1.013	(0.779)		
IA									0.311	(0.402)
Independent variables										
Minority	-0.073	(0.069)	-0.068	(0.068)	-0.077	(0.089)	-0.222	(0.131)	-0.066	(0.077)
Married	0.113	(0.069)	0.110	(0.071)	0.129	(0.070)	0.160	(0.073)	0.109	(0.070)
Male	0.449	(0.052)	0.452	(0.051)	0.456	(0.060)	0.417	(0.067)	0.449	(0.058)
Rural Background	-0.145	(0.058)	-0.141	(0.057)	-0.158	(0.068)	-0.220	(0.078)	-0.148	(0.059)
Education	0.089	(0.021)	0.087	(0.022)	0.100	(0.040)	0.178	(0.054)	0.094	(0.023)
Experience/10	0.242	(0.093)	0.237	(0.094)	0.273	(0.089)	0.476	(0.183)	0.303	(0.083)
(Experience/10)2	-0.045	(0.020)	-0.044	(0.020)	-0.052	(0.020)	-0.109	(0.047)	-0.055	(0.017)
Constant	8.422	(0.287)	8.443	(0.299)	8.252	(0.397)	7.662	(0.425)	8.093	(0.181)
Overidentification Test	5.1		4.6		5.5		5.7		4.5	
R2	0.307		0.308		0.306		0.307		0.307	
N	647		647		647		647		647	

Note: IJH: use of the Internet for job at home; CJH: use of a computer for job at home; IW: use of the Internet at work; CW: use of a computer at work; IA: use of the Internet for any purposes. Instruments are those listed in Table 2. The overidentification test is distributed $X^2(3)$ with a critical value of 7.8 at the .10 significance level.

Figure 1. The Number of High Speed Internet Access Providers within a Zipcode by Beale code



Beale code indicates Metro counties (BC = 0 – 3), Nonmetro counties (BC = 4 – 9).
More specifically, BC = 0: Large Metro Central, 1: Large Metro Fringe, 2: Medium Metro, 3: Small Metro, 4: Urbanized Adjacent, 5: Urbanized Nonadjacent, 6: Less Urban Adjacent, 7: Less Urban Nonadjacent, 8: Rural Adjacent, and 9: Rural Nonadjacent.