12-3-2012

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Keywords
internet, rural, urban, broadband, firm entry, metropolitan area

Disciplines
Economics

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Working Paper No. 12026
December 2012

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Abstract

The availability of broadband Internet service should have increased firm productivity and lowered firm entry costs. However, validating the broadband effect is complicated by the rapid deployment of broadband Internet service across metropolitan areas, removing meaningful variation in broadband availability. Deployment in rural markets was much more uneven, suggesting that the presence or absence of broadband service may have altered the site selection of firms targeting rural markets. We investigate the effect of broadband availability on firm location decision in rural Iowa. We establish a counterfactual baseline firm entry rate for each zip code area in rural counties by showing how the presence of broadband service in a ZIP code in 2001 affected firm entry in 1990-1992 before Broadband was available. We then measure how the actual presence of broadband service in the same ZIP code affected firm entry in 2000-2002. We show that the difference in estimated probability of entry between the counterfactual baseline and the actual response ten years later is the Difference-in-Differences estimate of the effect of broadband deployment on firm start-ups. We find that broadband availability in a rural ZIP code has a positive and significant effect on firm entry in the ZIP code but only in rural markets adjacent to a metropolitan area or with a larger urban population. Broadband access does not affect new firm entry in more remote rural markets.

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1. Introduction

It is widely presumed that access to broadband[2] lowers firm production costs and broadens the market for firm output. Both factors would raise the location-specific profitability of firms in areas with high-speed Internet access. In competitive markets, firms should have a higher probability of entering markets with higher anticipated profitability. However, demonstrating this effect has been complicated by the very rapid deployment of broadband service in urban areas. High-speed Internet deployment started in 1998 (Faulhaber, 2002) and was already available in most metropolitan markets within a year, eliminating meaningful variation in service availability in urban areas. That is not true in rural areas where there was considerable variation in access to broadband in the first few years of deployment.

A complicating factor is that high-speed Internet service will most likely be installed in areas that are already more profitable for new firm entry, requiring a control for preexisting, location-specific fixed factors that influence profitability even without the availability of high-speed Internet. Our need to control for location-specific fixed effects is apparent in Table 1. Broadband availability is positively correlated with firm entry in rural Iowa even before broadband was available anywhere in the United States. The correlations between firm entry in 1990 to 1992 and broadband availability in 1999 vary between 0.46 and 0.55 (p-values<0.01), similar to the correlation with firm entry in 2000. Moreover, the correlation between firm entry in 2000 and entry in the same zip code between 1990 and 1992 approaches 0.9. These correlations demonstrate why any effort to measure the effects of local broadband availability on growth must control for location-specific fixed effects.

If broadband services affect local firm profitability, the business decision that will be most sensitive to local presence or absence of high-speed Internet service will be the location decisions of new firm start-ups. Already existing firms are unlikely to change locations when broadband service

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[2] Broadband is a general term for communication technologies enabling “high-speed” data transmission. Usually broadband is contrasted with dial-up connection to Internet less than 56 Kbps. FCC defines data transmission faster than 200 Kbps in at least one direction “high-speed.” FCC (2005) provides shares of high-speed lines at the end of 1999: cable (51.3%), DSL (Digital Subscriber Line, 13.4%), fiber (11.3%), other wirelines (22.1%) and wireless and satellite (1.8%).

is rolled out because relocation is very expensive relative to the likely magnitude of broadband service on firm profits. Hence, studies that measure growth by changes in employment or output of already existing firms will confound growth due to broadband with growth due to preexisting conditions that led to past firm entry. Therefore, this study focuses on how broadband service affects the location decisions of firms entering business for the first time.

We develop a model that allows us to control for the impact of location-specific fixed effects in measuring how broadband access influences local firm entry decisions. The specification allows us to difference away the impact or pre-existing conditions on firm entry and to identify the independent effect of broadband access on local firm start-ups. As a result, we find that broadband availability in a ZIP code is likely to increase rural firm entry in Iowa. In particular, we find that the effect is significantly positive in more populated rural areas or rural markets adjacent to a metropolitan area. There is no impact of broadband access in more remote rural markets.

2. Literature Review

There is overwhelming evidence that Information Technology (IT) raises productivity (Jorgensen, 2001; Litan and Rivlin, 2001; Blinder, 2000). As one example, Jorgenson, Ho and Stiroh (2005) found that IT investments were responsible for 25% of total factor productivity growth and 22% of labor productivity growth between 1948-2002. The importance of IT has increased so that by 1995-2002, IT represented 66% of total factor productivity growth and 56% of labor productivity growth. Firms that adopted IT earlier experienced more rapid productivity gains than similar firms that did not (Dunne et al., 2004). Workers who worked in firms that used information technologies more intensely experienced faster wage growth than comparable workers in firms lacking IT investments (Acemoglu, 2002; Autor, Katz and Kruger, 1998). The mechanism by which IT raises firm productivity is that it decreases the cost of communication and information processing, and changes business processes and work practices (Brynjolfsson and Hitt, 2000). Grimes et al. (2012) provide an example from New Zealand: higher Internet connection speed through broadband raised firm productivity compared to firms with no connection or firms who only had access through dial-up service.

These IT investments have been strongly linked to faster economic growth at the country level. Röller and Waverman (2001) found that OECD countries grew faster as they approached near universal access to new telecommunications technologies. The review by Holt and Jamison (2009) concludes that growth attributed to IT was stronger in the U.S. than in Europe, but the growth was significant in both regions through the 1990s (Dimelis and Papaioannou, 2011). None of these studies dealt with broadband investments specifically.

Evidence of growth effects from broadband investments is less convincing. A challenge that has plagued all such studies is the endogeneity of broadband deployment. Economic growth in the United States has been concentrated in densely populated markets (Rosenthal and Strange, 2004), areas that also attracted early broadband deployment. That complicates identification of the unique broadband effect independent of correlated local factors that also affect growth. The review by Holt and Jamison (2009) notes that there are several studies that have found localized economic growth following broadband deployment, but all are subject to skepticism regarding their identifying restrictions. The best of these by Kolko (2012) uses average slope of local terrain as an instrument for the growth in local broadband in a study of the impact of broadband on employment growth. However, the results are extremely sensitive to specification changes[3] and are only valid if terrain has no direct impact on employment growth.

A second challenge faced by researchers is that the very rapid deployment of broadband eliminated most meaningful variation in access across urban markets. The Federal Communications Commission estimated that by 1999, 59% of ZIP codes representing 91% of the population had at least one provider (FCC, 2000, p.37), even though broadband deployment began in earnest just one year earlier. As a result, studies focused on the effects of broadband on growth in

[3] Estimated effects of broadband on employment in Table 6 in his paper are sensitive to weighting by employment. The effects are fluctuated between 0 and implausibly high value.

metropolitan areas have had to rely on variation in the number of providers rather than on the presence or absence of service, even though it is the latter that would presumably have the largest impact on growth. Furthermore, changes in the number of broadband providers in metropolitan markets would be due in part to the exit of providers from unprofitable areas as well as added providers to the most rapidly growing areas, adding an additional complication to establishing the direction of causality between broadband service and growth.

As shown in Figure 1, deployment was much slower in rural than in urban markets. Only one-fifth of the rural zip codes in Iowa had access by 1999 and the percentage did not reach 50% until December 2002. If it is the presence or absence of broadband that is most important for local economic growth as opposed to variation in the number of local broadband providers, there will be more fruitful variation to exploit in rural markets.

An additional advantage of studying the impact of broadband on economic development in rural areas is the near one-to-one correspondence between a community and a zip code. This is important because in the U.S., broadband deployment is reported at the zip code level. Consequently, one can tie growth of a distinct zip code market area to broadband service provision for the same area. In urban areas where broadband deployment is spread over multiple zip codes, it is more difficult to tie a market to a given zip code area.

There are also reasons to suspect that broadband service may be particularly important in rural markets. Agglomeration economies led to the creation of cities (Quigley, 1998; Glaeser, 2008) and explain the persistent wage gap favoring urban workers over rural workers (Renkow, 1996; Mills and Hazarika, 2001). The Internet has the potential to change the geography of production. Services may be produced at a distance from the customers of the service. Stages of production may be geographically dispersed and still coordinated. Consequently, proximity between employer and employee or customer and producer may become less important. The possibility of telecommuting also makes it potentially feasible for workers in rural areas to earn back some of the agglomeration surplus that previously only went to metropolitan workers. These possibilities have led some to conjecture that high-speed Internet will create communities of electronically linked rather than spatially linked individuals. Liebowitz (2002) predicted that the Internet will reduce the advantage of "locational monopolies" by which an urban company's proximity to its customers gave it a competitive advantage. If these conjectures are true, there should be substantial benefits for new firms to locate in rural areas that offer broadband service compared to rural areas that do not.

3. Model

We require a model that illustrates the role of locational fixed factors on new firm start-ups and that also offers an avenue by which those fixed factors may be held fixed in empirical applications. To that end, suppose that we have J markets (j=1, 2, …, J) which are defined geographically by the area containing one ZIP code area. We define t=0 for a period before high-speed Internet was available in any of the J markets. Period t=1 designates a time when high-speed Internet was available in at least some but not all of the J markets.

Production of firm i is given by

$$q_{ijt} \equiv A(I_{jt}, \mu_j)\, f(l_{it}, k_{it})$$

The firm uses inputs labor (l_{it}) and capital (k_{it}) to produce output q_{ijt}. Productivity is affected by a Hicksian aggregate total-factor productivity index, A which depends on the broadband availability, I_{jt}; and a vector of other local attributes that affect firm productivity which include a location-specific fixed effect μ_j. Firms locating in areas with high levels of A, those with strong fixed endowments μ_j or broadband Internet access I_{jt}, will have higher output per unit of input used.

Given the production function, price taking firms maximize their profit by choosing a market j so as to

$$Max\ \pi_{ijt} = p(z_{jt})\, q_{ijt} - c(q_{ijt}; w_{jt}, r_{jt})$$

Market price p is affected by a vector of location-specific but time-varying effects z_{jt}. Local wage w_{jt} and local rental rate on capital r_{jt} affect firm production cost. Without loss of generality, assume that the firm's highest profit will be in market j. Profit in market j will satisfy the condition

$\pi_{ijt}{}^{*} \geq \pi_{ij't}{}^{*}; j \neq j'$

Writing the profit function in general form,

$\pi_{ijt}{}^{*} \equiv \pi(w_{jt}, r_{jt}, z_{jt}, I_{jt}, \mu_{j})$.

Firm profits will depend on output which is priced competitively and on local wages and capital costs. If markets are competitive, firms will expect to make zero economic profits in all areas. Areas that acquire an additional endowment of *A* will find their firms gaining in productivity and profitability which will attract additional entry relative to areas that do not experience the shock to *A*. Entering firms will bid up the input prices for labor and capital until expected profits from additional entry are reduced back to zero. Hence, wages and rents will also be functions of local attributes such as μ_j and I_{jt}.

We illustrate the cross-sectional equilibrium pattern of wages and rents following the model advanced by Moretti (2004). We assume that firms and workers are freely mobile in a competitive market with location-specific productivity related to the presence or absence of high-speed Internet service. In Figure 2, we have two local markets A and B identical except broadband access. Market A has broadband access and Market B does not. Firms in Market A will be more productive than firms in Market B. Nevertheless, if workers and firms are mobile, equilibrium requires that worker utility and firm profit must be the same across the two markets. Firms seeking the higher productivity will bid up fixed factors such as land or quasi-fixed factors such as labor in Market A relative to Market B.

In equilibrium, land rents will adjust to firm entry incentives so that $r_A > r_B$. Workers in A will face higher housing costs relative to workers in B and must be compensated for the higher living costs relative to A. Workers' utility across the markets will equalize so that $V(w_A, r_A) = V(w_B, r_B) = \bar{V}$. That in turn requires that wages are higher in Market A than in Market B for equally skilled workers, $w_A > w_B$. For firm profits to be equal across the two markets, firms in Market A must pay sufficiently more for labor and capital to exactly neutralize the cost advantage from the higher profitability. Therefore, in wage-rent space, an iso-cost function per unit of output, normalized at 1, for firms in B,

$C(w_B, r_B, I_B=0)=1$ will lie everywhere below the same level of unit iso-cost for firms in A, $C(w_A, r_A, I_A=0)=1$. Firms will charge the same competitive price and will have equal profits across the two markets.

Absent any other sources of productivity differences between the two markets, wages and rents would have been identical in period 0 before broadband became available in any markets. Of course, that is too strong an assumption, and so we allow additional variation in local demand and location-specific labor productivity differences in the form of z_{j0} and μ_j. The linear approximation to our reduced form profit for firms in area *j* at time period 0 is

$$\pi_{ij0}^{*}\equiv\gamma_z^{0}z_{j0}+\gamma_\mu^{0}\mu_j+\varepsilon_{j0}+\varepsilon_0 \qquad (1)$$

where superscripts on the parameters indicate the time period. The error term ϵ_{j0} reflects transitory factors that the firm observes in assessing its profits in area *j* but that are not observed by the econometrician. ϵ_0 is a common factor that affects profitability in all areas such as a state-wide expansion or recession. We assume that these unobserved factors are uncorrelated with the location-specific fixed factors and the observed time-varying factors.

By time period 1, high-speed Internet service is available in some of the markets. The linearized reduced-form firm profit is given by

$$\pi_{ij1}^{*}\equiv\gamma_z^{1}z_{j1}+\gamma_\mu^{0}\mu_j+\gamma_I^{1}I_{j1}+\varepsilon_{j1}+\varepsilon_1 \qquad (2)$$

In principle, if we observe the fixed effect μ_j, we can estimate (2) directly. However, we do not observe μ_j. However, we do observe exogenous instruments for μ_j, namely the observed local economic factors z_{j1} and the presence or absence of broadband Internet service. Consider the linear projection of the area *j* fixed effect on I_{j1} and z_{j1}:

$$\mu_j\equiv\theta_z^{1}z_{j1}+\theta_I I_{j1}+\omega_j \qquad (3)$$

where ω_j is an *iid* error composed of elements of the fixed effect that are uncorrelated with the presence of broadband or of other local market factors. Then (1) can be rewritten

$$\pi_{ij0}^{*}\equiv\gamma_z^{0}z_{j0}+\gamma_\mu^{0}\theta_z^{1}z_{j1}+\gamma_\mu^{0}\theta_I I_{j1}+\gamma_\mu^{0}\omega_j+\varepsilon_{j0}+\varepsilon_0 \qquad (1')$$

Similarly, equation (2) will take the form

$$\pi_{ij1}{}^{*}\equiv(\gamma_z{}^{1}+\gamma_\mu{}^{0}\theta_z{}^{1})z_{j1}+(\gamma_\mu{}^{0}\theta_I+\gamma_I{}^{1})I_{j1}+\gamma_\mu{}^{0}\omega_j+\varepsilon_{j1}+\varepsilon_1 \quad (2')$$

Each new firm chooses one of the potential J markets to enter, based on anticipated profitability. Define the dichotomous variable E_{ij0}=1 if the firm opts to enter market j in period 0 and E_{ij0}=0 otherwise. E_{ij0}=1 if $\pi_{ijt}{}^{*}-\pi_{ij't}{}^{*}\geq 0 \quad \forall j\neq j'$. Inserting the specification for profit (1') and (2'), we have

$$E_{ij0}=1 \text{ if } \gamma_z{}^{0}(z_{j0}-z_{j'0})+\gamma_\mu{}^{0}\theta_z{}^{1}(z_{j1}-z_{j'1})+\gamma_\mu{}^{0}\theta_I(I_{j1}-I_{j'1})>\zeta_{ij0}, \quad \forall j\neq j' \quad (4)$$

where $\zeta_{ij0}\equiv(\gamma_\mu{}^{0}\omega_{j'}+\varepsilon_{j'0})-(\gamma_\mu{}^{0}\omega_j+\varepsilon_{j0})$. Note that the common economic shock ε_0 is differenced away as it does not affect relative profitability across markets. In addition, if the error term $\gamma_\mu{}^{0}\omega_j+\varepsilon_{j0}$ follows the type 1 extreme distribution, we can estimate (4) using the conditional logit estimator.

We will have a similar specification for firm choices in period 1:

$$E_{ij1}=1 \text{ if } (\gamma_z{}^{1}+\gamma_\mu{}^{0}\theta_z{}^{1})(z_{j1}-z_{j'1})+(\gamma_\mu{}^{0}\theta_I+\gamma_I{}^{1})(I_{j1}-I_{j'1})>\zeta_{ij1}, \quad \forall j\neq j' \quad (5)$$

where $\zeta_{ij1}\equiv(\gamma_\mu{}^{0}\omega_{j'}+\varepsilon_{j'1})-(\gamma_\mu{}^{0}\omega_j+\varepsilon_{j1})$.

We can identify effect of broadband availability, $\gamma_I{}^{1}$ by estimating (4) and (5) jointly as:

$$E_{ijt}=1 \text{ if } \gamma_z{}^{0}D_{t=0}\cdot(z_{j0}-z_{j'0})+\gamma_\mu{}^{0}\theta_z{}^{1}(z_{j1}-z_{j'1})+\gamma_z{}^{1}D_{t=1}\cdot(z_{j1}-z_{j'1})+\gamma_\mu{}^{0}\theta_I(I_{j1}-I_{j'1})+\gamma_I{}^{1}D_{t=1}(I_{j1}-I_{j'1})>\zeta_{ijt}, \quad \forall j\neq j'; j=1,2,\ldots,J \quad (6)$$

where $\zeta_{ijt}\equiv(\gamma_\mu{}^{0}\omega_{j'}+\varepsilon_{j't})-(\gamma_\mu{}^{0}\omega_j+\varepsilon_{jt})$, and $D_{t=\tau}$ is a dummy variable indicating time period τ. Critically, this specification shows that the effects of the location-specific fixed factors on period 1 profitability, $\theta_z{}^{1}$ and θ_I, are captured as baseline coefficients on $(z_{j1}-z_{j'1})$ and $(I_{j1}-I_{j'1})$. This allows the broadband effect, $\gamma_I{}^{1}$, to be identified as the additional effect captured by the coefficient on the interacted term $D_{t=1}(I_{j1}-I_{j'1})$. The estimate of $\gamma_I{}^{1}$ is purged of possible correlation with the location-specific fixed effects and common cyclical factors.

Note a distinct advantage of our use of new firm locations decisions as our firm choice. These firms are all making their location decisions based on their knowledge of relative expected profitability of their firm in alternative locations. More aggregated growth measures used in other studies such as the number of firms, employees or output in an area do not only reflect current and future profitability but also past profitability when the majority of local firms were born. Because it is costly to relocate, these alternative measures may be unresponsive to recent changes in the local factors that affect profit.

A complication of our empirical model is the sheer number of alternatives: the full choice set consists of 630 rural ZIP codes. Setting J=630 is computationally infeasible. McFadden (1978) showed that estimators based on a smaller representative choice set will generate consistent estimates. Therefore, for each firm start-up location decision, we use a smaller choice set containing 30 ZIP codes: the one ZIP code actually chosen by the start-up, and 29 ZIP codes randomly drawn from the ($J-1$) unchosen ZIP codes.

Our identification of the true broadband effect on entry relies on assumption of independence between broadband availability (I_{jt}) and error terms ($\gamma_\mu^0\omega_j+\varepsilon_{jt}+\varepsilon_t$). If this assumption is violated, then estimates of γ_I^1 will be biased. The violation occurs if unobserved, transitory shocks to firm i's profitability in ZIP code j in period 1 are also affecting the probability of broadband provision in ZIP code j. To pose problems, these shocks must be uncorrelated with the location-specific fixed effect, μ_j, that has been differenced away using our estimation strategy; must be uncorrelated with the common time effects, ε_t; and must be uncorrelated with the included elements of z_{j0} and z_{j1}, namely local per capita income and education levels. In other words, our results have been purged of possible bias due to local factors that affect local firm profitability over time, time-specific factors that affect firm profitability across localities in a given year, or by observed local socioeconomic factors that vary over time.

4. Data

We focus on ZIP code areas in rural counties. We define ZIP code areas located in counties with urban population less than 20,000 (RUCC 6 to 9) as "rural". We use Rural-Urban Continuum Codes (RUCC) released in 1993, which is county classification made by ERS (Economic Research Service), U.S. Department of Agriculture based on size of urban population and proximity to Metropolitan Statistical Area (MSA)[4].

We base our test of the model on a sample of 24,290 "commercial" establishments that entered a rural Iowa ZIP code area in the periods 1990-1992 and 2000-2002[5]. We restrict the sample to firms with a clear profit motive, and so we exclude non-profit organizations, government agencies and establishments with a public service emphasis such as museums or historical sites. We also remove firms in agriculture and mining because they cannot move freely across locations as their entry decision is affected by site-specific land or resource availability[6].

Firm attributes such as county-level and ZIP code-level location and industry are obtained from the National Establishment Time Series (NETS) which provides information on the universe of all firms that opened for business in 1990-1992 or 2000-2002 in Iowa that had a Duns number. Panel (a) of Table 2 shows the number of firms entering by RUCC. Over six years (1990-1992 and 2000-2002), on average, ZIP code areas located in the more populous rural counties (RUCC 6 and 7) had 44 entrants while Zip code areas in the less populated counties (RUCC 8 and 9) had about 25.

Our key explanatory variable is the presence of broadband in a ZIP code area. The Federal Communications Commission (FCC) Form 477 reports the number of broadband service providers

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[4] Counties in RUCC 6 and 7 have urban population of 2,500 to 19,999 while those in RUCC 8 and 9 have less than 2,500 urban populations. Counties in RUCC 6 and 8 are adjacent to a metropolitan statistical area while those in RUCC 7 to 9 are not.

[5] There were 35,096 new firms entered rural Iowa over six years (1990-1992 and 2000-2002). We obtain 24,519 new firms after excluding new firms not satisfying our criteria for commercial firms. In addition, 211 firms are excluded because they are not matched with ZIP codes available in both 1990 and 2000 Census.

[6] The following industries are excluded: Agriculture (2-digit 2002 NAICS 11), Mining (22), Postal Service (3-digit NAICS 491), Monetary Authorities-Central Bank (521), Nursing and Residential Care Facilities (623), Social Assistance (624), Museums, Historical Sites, and Similar Institutions (712), Religious, Grantmaking, Civic, Professional and Similar Organizations (813), Private Households (814), and Public Administration (2-digit NACIS 92).

with subscribers in each ZIP code. The data include satellite broadband which is not area specific. That is not a problem because the other types of service are area-specific and could therefore affect the entry decision, and in any event, satellite subscriptions represent a small share of the broadband market.[7]

Form 477 may underreport broadband service availability because companies are not required to report their presence in a ZIP code until they have at least 250 lines. Kolko (2010) demonstrated that broadband availability reported in the FCC data is consistent with residential broadband availability obtained from a second survey that was not similarly constrained, and so the problem does not appear to be severe.

The other included time-varying local attributes, z_{jt}, are the average education and the per capita income level of residents in that ZIP code area. The education variable is measured by people over 25 years old with at least a two-year college degree in that ZIP code, and the income variable is median household income in that ZIP code area. Those measures are available from the 1990 and 2000 Census. Given significant travel costs, these variables are expected to reflect local demand for goods and services that are presumed to have an impact on local firm profitability.

Panel (b) in table 2 presents summary statistics on education and income of sample ZIP codes. Education and income levels increase over time which could improve the climate for new firm entry over time. That is why it is important to include these time varying, location-specific attributes into the analysis so that their effect is not incorrectly captured by their correlation with local broadband availability. There is little difference in education levels across more or less populated rural counties, but average incomes are higher in counties that are adjacent to metropolitan areas.

We include 630 ZIP Code Tabulation Areas (ZCTA) in our data set. We required a consistent geographical area over the two periods separated by ten years. We assume that when the ZCTA code does not change over time, the geographical boundaries are also consistent between 1990 and 2000. Of 671 rural ZCTA codes in 2000, 631 were matched to corresponding 1990 Census ZIP

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[7] In December 1999, satellite broadband and terrestrial wireless services had a 1.8% share of high-speed broadband market. (FCC, 2005)

codes exactly. ZIP codes included in the 1990 Census which do not have the same 2000 ZCTA code were merged into the ZCTA closest to them in terms of distance between midpoints. One ZCTA was excluded because it did not have any firm entrants in any of the six years (1990-1992 and 2000-2002).

5. Results

The estimated effects of broadband availability on rural firm entry are reported in Table 3. To allow for possible reporting error on which ZIP codes had service, we replicate the same specification with three measures of reported broadband availability as reported in December of 1999, 2000, and 2001. All estimates include controls for ZIP code specific fixed effects (μ_j) common time effects across ZIP codes (ε_t), and observed time-varying location-specific factors (z_{ijt}) for both periods. The estimated difference-in-differences impact of broadband availability on firm entry is reported as γ_I^1 in the broadband effect row. The location-specific fixed effect on firm entry is reported as $\gamma_\mu^0\theta_I$ from equation (4). In column (1) with counterfactual broadband availability as of December 1999, the estimate of γ_I^1 is 0.09. The corresponding estimates with counterfactual broadband measured as of December 2000 and December 2001 are 0.06 and 0.18, respectively. All of the estimated effects are statistically significant at least at 10% significance level. Our finding that broadband raises the firm entry rate is consistent with positive correlations between broadband availability and growth in the number of firms (Gillette et al. , 2006; Mack et al., 2011) or growth in employment. (Kolko, 2012)

The coefficients are difficult to interpret, so we derive their implied elasticities using the following equation.

$$\varepsilon_I = \frac{\frac{dP_{ij}}{dI_{j1}}}{\overline{P_{ij}}} \cdot \overline{I_{j1}} \approx \frac{\sum_{i=1}^{N}\sum_{j=1}^{J}\frac{P_{ij}(I_{j1}=1)-P_{ij}(I_{j1}=0)}{P_{ij}(I_{j1}=0)}}{N\cdot J} \cdot \frac{\sum_{j=1}^{J} I_{j1}}{J}$$

where N is the number of entering firms and J is the number of ZIP code areas. The first term is an average of percentage changes in the marginal effect of broadband availability. The marginal effect is measured by the estimated difference between $P_{ij}(I_{j1}=1)$: the fitted probability that a firm i enters market j when broadband is available; and $P_{ij}(I_{j1}=0)$: the corresponding fitted probability of entry in the same ZIP code when broadband is not available. The second term is the ratio of ZIP codes with broadband service relative to the total number of ZIP codes. The elasticities are shown in the brackets under estimates for γ_I^1. The estimates range from 0.02 to 0.06. In other words, if 10% more rural ZIP codes have broadband access, then rural firm entry increases by 0.2 to 0.6%.

In table 4, we apply the empirical method to subsets of the data defined by proximity to a metropolitan area and by size of urban population. It is immediately apparent that the positive impacts of broadband availability on firm entry is significantly positive only in rural ZIP codes located in counties with more urban populations and that are adjacent to a metropolitan statistical area (RUCC 6). The implied elasticities decrease in size as the county population becomes more rural and more distant from a metropolitan market. In the adjacent counties with urban populations above 2,500 (RUCC 6), the elasticity is 0.16, and so a 10% increase in broadband availability in these counties raises firm entry by 1.6%. In rural counties with similar urban population size but not adjacent to a metropolitan area, the implied increase in probability of firm entry is only 0.2%. In the counties with less than 2,500 urban residents, there is no apparent impact on the probability of firm entry from greater broadband availability. The implication is that firm profitability is only affected by broadband availability in rural counties that are adjacent to a metropolitan area, and so broadband does not help economic development in more remote or less populous rural markets.

One of goals of the USDA Rural Broadband Loan Program is to attract businesses[8]. This program has invested more than $1 billion over the last decade[9]. Our findings suggest that these investments have negligible effects except for rural areas adjacent to a metropolitan area. This is consistent with Kandilov and Renkow (2010) finding that positive economic outcomes of the pilot

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[8] Link for Rural Broadband Loan Program Brochure: http://www.rurdev.usda.gov/supportdocuments/BBLoanProgramBrochure_8-11.pdf (Accessed on Aug. 1, 2012)
[9] U.S. Department of Agriculture News Release No. 0109.11, March 10, 2011

loan program are mainly observed in communities close to urban areas. We examine whether the broadband effects differ by industry. It is possible that the effects are too small to measure overall, but that broadband is of particular importance to a subset of sectors sited in rural areas. The joint test that the broadband effect is common across industries is reported toward the bottom of Table 5. We reject the null hypothesis of a common broadband effect in the regression pooling all observations (RUCC 6 to 9), and also for the regressions on the subsample of non-adjacent counties with urban populations above 2,500 (RUCC 7). In those samples, the only sector with a broadband effect that deviates from the all-industry norm is professional and business services. We fail to reject the null hypothesis of a common industry effect both jointly and sector-by-sector in the rural counties with rural continuum codes 6, 8 and 9. Consequently, the source of the rejection is the single finding that in RUCC7, broadband service lowers the likelihood of entry of a professional or business service firm. While this may be possible, we suggest that the broader evidence suggests that broadband presence did not have a particular bias toward one industry over another. Grimes (2012) also found that broadband did not differentially affect firm productivity in 'high knowledge' and 'low knowledge' intensive firms. Kolko (2012) concluded that the number of broadband service providers is positively correlated with employment growth in information technology-intensive industries, but his industry estimates did not correct for a likely reverse causal effect.

Our results are still open to the possibility that unobservable transitory location-specific factors are jointly influencing firm entry and broadband installation creating a non-causal correlation between broadband access and firm entry. We have no direct test of the validity of our assumption, but we can test whether areas that had typically high number of firm entries in the 1990s before broadband was available anywhere were the areas that benefited the most from broadband availability. Our presumption is that if our assumed identification is invalid, an underlying correlation between the numbers of firm entries in the past would be correlated with both broadband availability and the number of firm entries in the 2000s. We divided our ZIP codes into four groups in ascending order of the number of firm entries in 1990-1992. Then we compare estimates for broadband availability in the broadband effect rows in table 6. Although the estimates are not always precise, the estimated broadband effect in the counties with the fewest entrants in 1990-92 is not significantly different than the broadband effect for the counties with the most firm entrants a decade earlier. Therefore, we do not believe our estimated broadband effect is being driven by an unobserved factor that raises both the firm entry rate and the probability of a local broadband provision.

The literal interpretation of our finding that broadband raises the local rural firm entry rate in counties adjacent to a metropolitan area suggest that broadband presence raises firm profitability. This has to be a transitory effect as other markets for labor and capital should adjust to cause wages and rents to rise in markets where broadband raises productivity, causing profits to equalize across markets with or without broadband access as indicated in Figure 2. There is some evidence supportive of those wage and rent effects. Gillette et al. (2006) find that broadband Internet is positively associated with rents. Wages are less sensitive to broadband availability. Forman et al. (2012) find that high-speed Internet does not affect wage rates except in places with highly educated and more dense urban populations with concentrations of IT-intensive industries. Kolko (2012) finds no effect of broadband on average wages. Because capital is less mobile than labor, these findings suggest that the equalizing factor may come from a bidding up of land prices in areas that have broadband access.

6. Conclusion

We propose an estimation strategy controlling for the correlation between broadband availability and location-specific fixed effects. We can distinguish the impacts of unobserved location-specific fixed effects on firm entry from the true effects of broadband availability by estimating the counterfactual effect of broadband availability on past local firm entry. In addition, our focus on the location decisions of newly entering firms insures that these firm decisions are not confounded by past factors affecting firm entry as would be the case with employment or output growth across all local firms.

We have shown positive and significant effects of broadband availability on firm entry in rural Iowa. Interestingly, the effect is significantly positive only in rural ZIP code areas located in counties with larger urban populations and that are adjacent to a metropolitan statistical area. This is consistent with the presumption that broadband can broaden the extent of the labor market and product market of rural firms within commuting distance of a concentration of potential employees and customers. In contrast, there is no impact of broadband availability on firm entry in more remote rural ZIP codes, implying that government investment in rural broadband installment has a negligible impact on firm entry or profitability for those areas.

Acknowledgements

We thank Wallace Huffman and Brent Kreider for helpful comments and Liesl Eathington for dealing with geographic information system.

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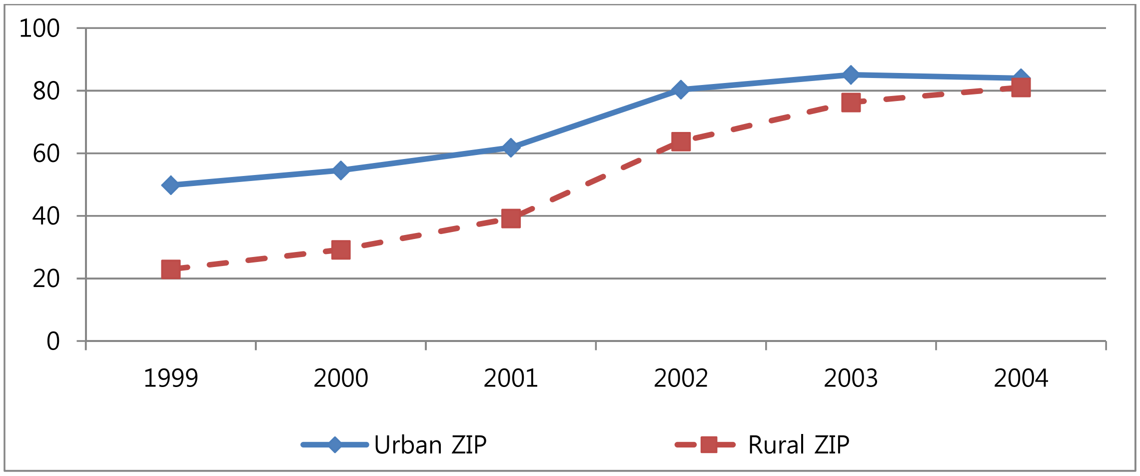

Figure 1 Percentiles of ZIP codes with broadband Internet in Iowa in 1999 to 2004

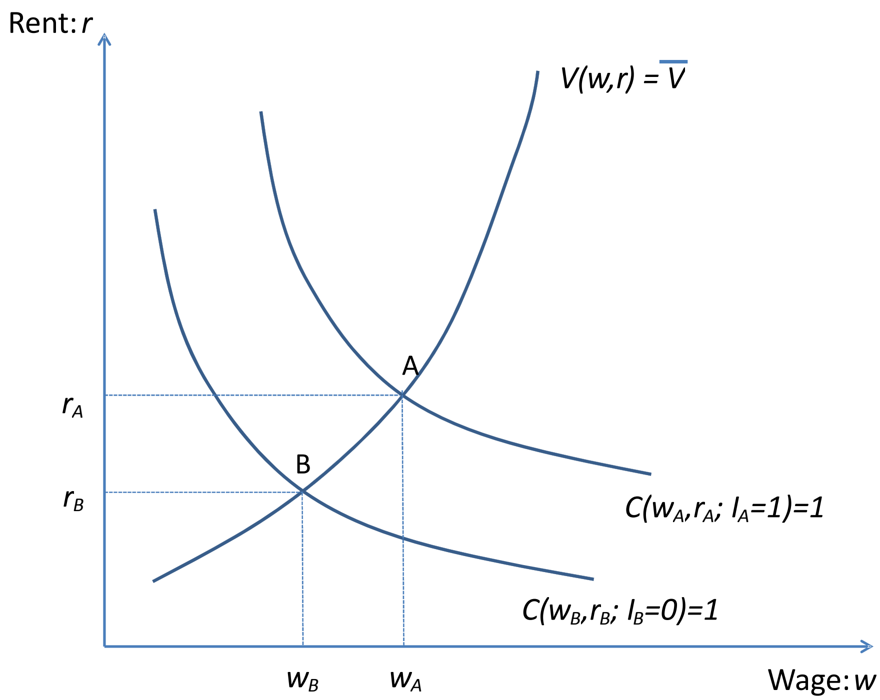

Figure 2 Equilibrium local wages and rental rates on capital when broadband availability affects firm productivity

Table 1
Correlation between broadband availability and sample firm entry in rural Iowa[a]

		Broadband availability as of Dec. 1999	# of firm entry at ZIP code area			
			1990	1991	1992	2000
Broadband availability as of Dec. 1999		1	-	-	-	-
# of firm entry at ZIP code area	1990	0.574	1			-
	1991	0.479	0.878	1		-
	1992	0.571	0.862	0.807	1	-
	2000	0.571	0.892	0.853	0.885	1

[a] P-values for all the correlations are less than 0.01. Note that the rural ZIP code areas are located in counties with urban population less than 20,000.

Table 2

Sample Firm Entry and Summary Statistics

Panel (a) Sample firm entry in rural Iowa

	Counties with RUCC 6	Counties with RUCC 7	Counties with RUCC 8	Counties with RUCC 9	Total
1990	921	1,202	187	214	2,524
1991	607	803	124	135	1,669
1992	1,419	1,792	429	328	3,968
2000	1,502	1,797	333	322	3,954
2001	2,483	3,184	549	570	6,786
2002	1,973	2,594	406	416	5,389
Total	8,905	11,372	2,028	1,985	24,290
Average per ZIP code area	43	44	30	21	39

Panel (b) Education and income in rural Iowa

		1990		2000		# of sample ZIP codes	# of counties
		Mean	S.D.	Mean	S.D.		
Education	RUCC 6	0.16	0.05	0.19	0.07	206	24
	RUCC 7	0.18	0.06	0.20	0.06	260	36
	RUCC 8	0.15	0.06	0.19	0.06	68	8
	RUCC 9	0.17	0.07	0.19	0.06	96	12
Income	RUCC 6	24.6	4.47	28.8	4.70	206	24
	RUCC 7	23.3	3.42	26.9	3.22	260	36
	RUCC 8	23.8	4.03	28.1	5.27	68	8
	RUCC 9	21.5	4.03	24.8	3.98	96	12

Table 3

Effect of broadband availability on firm entry in rural Iowa[a]

Dependent Var.: Choice of Area		ZIP codes in rural counties		
		(1)	(2)	(3)
Baseline	Broadband availability by 1999: $\gamma_\mu^0\theta_I$	1.36 (0.03)***	-	-
	Broadband availability by 2000: $\gamma_\mu^0\theta_I$	-	1.38 (0.03)***	-
	Broadband availability by 2001: $\gamma_\mu^0\theta_I$	-	-	1.27 (0.03)***
-	Education and Income in 1990 for firm entry in 1990-1992	Yes	Yes	Yes
	Education and Income in 2000 for firm entry in all six years	Yes	Yes	Yes
	RUCC-specific Dummies for firm entry in all six years	Yes	Yes	Yes
Broadband Effect	Broadband availability by 1999 (or 2000 and 2001) for firm entry in 2000 (or 2001 and 2002, respectively): γ_I^1	0.09 (0.03)*** [0.03]	0.06 (0.03)* [0.02]	0.18 (0.03)*** [0.06]
-	Education and Income in 2000 for firm entry in 2000-2002	Yes	Yes	Yes
	RUCC-specific Dummies in firm entry in 2000-2002	Yes	Yes	Yes
Mean log-likelihood		-2.99876	-3.00059	-3.01347
Observations		24,290	24,290	24,290

[a]Standard errors are in parentheses. Elasticities are in the brackets. ***, ** and * indicate significance at the 1%, 5%, or 10% level.

Table 4

Effect of broadband availability on firm entry in rural Iowa by RUCC[a]

Dependent Variable: Choice of Area		ZIP codes in counties with RUCC 6	ZIP codes in counties with RUCC 7	ZIP codes in counties with RUCC 8	ZIP codes in counties with RUCC 9
		(1)	(2)	(3)	(4)
Baseline	Broadband availability by 2001: $\gamma_\mu{}^0\theta_I$	1.20 (0.05)***	1.52 (0.05)***	0.87 (0.06)***	1.05 (0.13)***
-	Education and Income in 1990 for firm entry in 1990-1992	Yes	Yes	Yes	Yes
	Education and Income in 2000 for firm entry in all six years	Yes	Yes	Yes	Yes
Broadband Effect	Broadband availability by 1999 (or 2000 and 2001) for firm entry in 2000 (or 2001 and 2002, respectively): $\gamma_I{}^1$	0.37 (0.06)*** [0.16]	0.07 (0.05) [0.02]	0.01 (0.08) [0.01]	-0.04 (0.24) [-0.01]
-	Education and Income in 2000 for firm entry in 2000-2002	Yes	Yes	Yes	Yes
Mean log-likelihood		-3.02962	-2.94771	-3.22227	-3.24153
Observations		8,905	11,372	2,820	1,985

[a] Standard errors are in parentheses. Elasticities are in the brackets. ***, ** and * indicate significance at the 1%, 5%, or 10% level.

Table 5

Effect of broadband availability on firm entry in rural Iowa by industry[a]

Dependent Variable: Choice of Area		ZIP codes in counties with RUCC 6 to 9	ZIP codes in counties with RUCC 6	ZIP codes in counties with RUCC 7	ZIP codes in counties with RUCC 8	ZIP codes in counties with RUCC 9
		(1)	(2)	(3)	(4)	(5)
Baseline	Broadband availability by 2001×Eight industrial dummies	Yes	Yes	Yes	Yes	Yes
	Broadband availability by 2001	Yes	Yes	Yes	Yes	Yes
-	Education and Income in 1990 for firm entry in 1990-1992	Yes	Yes	Yes	Yes	Yes
	Education and Income in 2000 for firm entry in all six years	Yes	Yes	Yes	Yes	Yes
	RUCC-specific Dummies for firm entry in all six years	Yes	-	-	-	-
Broadband Effect by Industry	Construction[+]	-0.11 (0.13)	0.12 (0.21)	-0.15 (0.20)	-0.24 (0.39)	0.00 (0.38)
	Manufacturing[+]	-0.25 (0.17)	0.08 (0.30)	-0.39 (0.27)	-0.32 (0.51)	-0.03 (0.52)
	Trade, Transportation and Utilities[+]	-0.02 (0.11)	0.18 (0.19)	0.02 (0.17)	-0.59 (0.33)*	0.29 (0.35)
	Information[+]	0.32 (0.26)	0.70 (0.45)	-0.08 (0.42)	0.54 (0.88)	1.05 (0.86)
	Financial Activities[+]	0.11 (0.14)	0.35 (0.23)	0.08 (0.21)	-0.30 (0.41)	-0.07 (0.42)
	Professional and Business Services[+]	-0.34 (0.14)**	-0.27 (0.23)	-0.42 (0.22)*	-0.28 (0.39)	0.04 (0.40)
	Education and Health Services[+]	-0.05 (0.18)	-0.08 (0.33)	0.21 (0.29)	-0.71 (0.56)	0.43 (0.52)
	Leisure and Hospitality[+]	0.08 (0.15)	0.39 (0.26)	0.33 (0.23)	-0.79 (0.45)*	0.00 (0.68)
	Broadband availability (Baseline=Other Services)	0.21 (0.10)**	0.21 (0.16)	0.07 (0.15)	0.44 (0.28)	-0.18 (0.31)
-	Education and Income in 2000 for firm entry in 2000-2002	Yes	Yes	Yes	Yes	Yes
	RUCC-specific Dummies in firm entry in 2000-2002	Yes	-	-	-	-
Mean log-likelihood		-3.00973	-3.02289	-2.94439	-3.22005	3.24349
Joint hypothesis of equal broadband effects across industries[++] [p-value]		11.49 [0.01]	11.75 [0.11]	14.75 [0.04]	4.66 [0.70]	3.69 [0.81]
Observations		24,290	8,905	11,372	2,028	1,985

[a] Note that industries with a sign '+' are interacted with broadband availability by 1999 (or 2000 and 2001) for entry in 2000 (or 2001 and 2002, respectively). ++: The null hypothesis is that sector-specific estimates of effects of broadband availability on firm entry are the same across sectors. ***, ** and * indicate significance at the 1%, 5%, or 10% level.

Table 6

Robustness check: effect of broadband availability on firm entry in selected ZIP code areas in rural Iowa[a]

Dependent Var.: Choice of Area		Quantiles of ZIP codes areas in terms of the # of firm entry in 1990 to 1992			
		0~25% (1)	25.1~50% (2)	50.1~75% (3)	75.1~100% (4)
Baseline	Broadband availability by 2001	0.22 (0.14)	0.02 (0.09)	0.07 (0.06)	0.42 (0.05)***
-	Education and Income in 1990 for firm entry in 1990 to 1992	Yes	Yes	Yes	Yes
	Education and Income in 2000 for firm entry in all six years	Yes	Yes	Yes	Yes
	RUCC-specific Dummies in all six years	Yes	Yes	Yes	Yes
Broadband Effect by Firm Growth Quantiles in 1990-1992	Broadband availability by 1999 (or 2000 and 2001) for firm entry in 2000 (or 2001 and 2002, respectively)	0.24 (0.18)	0.24 (0.12)**	0.17 (0.07)**	0.12 (0.06)*
-	Education and Income in 2000 for firm entry in all six years	Yes	Yes	Yes	Yes
	RUCC-specific Dummies in 2000 to 2002	Yes	Yes	Yes	Yes
Mean log-likelihood		-3.38949	-3.38731	-3.38587	-3.29985
Number of firm entry		1,325	1,772	3,969	17,052
Number of ZIP code areas		186	118	145	181

[a] Note that ZIP code areas are sorted in ascending order of the number of firm entries in 1990-1992. Standard errors are in parentheses. ***, ** and * indicate significance at the 1%, 5%, or 10% level.