Broadband and Economic Development: A Municipal Case Study from Florida

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In this paper, we explore whether broadband investment by municipalities has an effect on economic growth. To do so, we employ an econometric model to compare economic growth in Lake County, Florida, with other similar Florida counties. In 2001, Lake County – a small county in central Florida – began generally offering private businesses and municipal institutions access to one of Florida's most extensive, municipally-owned broadband networks, with fiber optic connections to hospitals, doctor offices, private businesses, and 44 schools.[1] Our econometric model shows that Lake County has experienced approximately 100% greater growth in economic activity – a doubling – relative to comparable Florida counties since making its municipal broadband network generally available to businesses and municipal institutions in the county. Our findings are consistent with other analyses that postulate that broadband infrastructure can be a significant contributor to economic growth. Our results suggest that efforts to restrict municipal broadband investment could deny communities an important tool in promoting economic development.

I. Introduction

The future of a community is often directly related to that community's public infrastructure. Good schools, adequate roads and transportation, access to affordable health care, and quality of life factors such as parks and cultural venues play a role in whether communities will attract new businesses and residents and be vibrant. Economic research shows that public infrastructure investment is a powerful driver of business productivity, investment, and economic growth.[2]

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1 The municipality began construction and use of the network in 1992, but its use was very limited prior to the 2001 service expansion.

2 Research on the topic include, e.g., D. A. Aschauer, *Is Public Expenditure Productive*?, 23 JOURNAL OF MONETARY ECONOMICS 177-200 (1989); U. Blum, *Effects of Transportation Investments on Regional Growth: A Theoretical and Empirical Investigation*, 49 PAPERS AND PROCEEDINGS OF THE REGIONAL SCIENCE ASSOCIATION 169-184 (1982); K. J. Button, S. Leitham, R. W. McQuaid, and J. D. Nelson, *Transport and Industrial and Commercial Location*, 29 ANNALS OF REGIONAL SCIENCE 189-206 (1995); E. Gramlich, *Infrastructure Investment: A Review Essay*". XXXII JOURNAL OF ECONOMIC LITERATURE 1176-1196 (1994); I. Nadiri and T. Mamuneas, *The Effects of Public Infrastructure and R&D Capital on the Cost Structure and Performance of U.S. Manufacturing Industries*,

In the twenty-first century, cities and counties are beginning to recognize that broadband telecommunications infrastructure is just as important – if not more important – than other areas of public infrastructure.[3] Unfortunately, according to the Organization of Economic Cooperation and Development, the United States ranks 13th in broadband penetration among industrialized nations.[4] Noted technology entrepreneur and scholar Charles H. Ferguson has stated that the cost of local telecommunications services "is the largest financial and economic impediment to universal Internet access" in the United States and that the rate of progress in the U.S. local telecommunications "is the lowest of any information technology industry."[5]

Political leaders are taking notice: President Bush has stated that all corners of the nation must have "universal, affordable" broadband service by 2007.[6] President Bush observed that a broadband network is a "great opportunity" for a community.[7] Leaders are concerned that communities without broadband service will wither and be left behind as firms and jobs move to regions – either elsewhere in the U.S. or abroad – where instant, high-bandwidth connectivity is available and affordable. For example, FCC Commissioner Michael J. Copps has observed:

> [p]roviding meaningful access to advanced telecommunications for all our citizens may also spell the difference between stagnation and economic revitalization. One study estimates that universal broadband access could add half a trillion dollars to the U.S. economy every year. Even that may be conservative. Broadband is already becoming key to our nation's systems of education and commerce and jobs and, therefore, key to America's future. It's

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LXXVI REVIEW OF ECONOMICS AND STATISTICS, 189-198 (1994). H. Seitz, *The Productivity and Supply of Urban Infrastructures*, 29 ANNALS OF REGIONAL SCIENCE 121-141 (1995); H. Seitz and G. Licht, *The Impact of Public Infrastructure Capital on Regional Manufacturing Production Cost*, 29 REGIONAL STUDIES 231-240 (1995).

[3] UTOPIA, a consortium of 14 Utah cities, states "[t]elecommunications infrastructure today is just as vital for economic growth as transportation systems were in the past. . . . Cities have always been in the infrastructure business." Utah Telecommunications Open Infrastructure Agency, *White Paper: Utah's Public-Private Fiber-to-the-Premises Initiative* (Nov. 2003), http://www.utopianet.org/downloads/Utopia_White_Paper.pdf ("UTOPIA White Paper") at 7-8. For examples of current city networks and proposals, *see* MuniWireless, http://www.muniwireless.com/archives/cat_hot_cities.html.

[4] International Telecommunications Union, ITU INTERNET REPORTS 2004: THE PORTABLE INTERNET (2004).

[5] Charles H. Ferguson, THE BROADBAND PROBLEM: ANATOMY OF A MARKET FAILURE AND A POLICY DILEMMA (2004) at 8, 41.

[6] The White House, *A New Generation of American Innovation* (April 2004), http://www.whitehouse.gov/infocus/technology/economic_policy/200404/innovation.pdf, at 11.

[7] President Bush said in a June 24, 2004 speech: "Imagine if you're the head of a chamber of commerce of a city, and you say, 'Gosh, our city is a great place to do business or to find work. We're setting up a wi-fi hot zone, which means our citizens are more likely to be more productive than the citizens from a neighboring community.' It's a great opportunity." The White House, *President Bush: High Tech Improving Economy, Health Care, Education* (June 2004), http://www.whitehouse.gov/news/releases/2004/06/020040624-7.html.

> going to be front-and-center in America's Twenty-first century transformation. Bet on it. "[8]

With these stakes, it is no surprise that some municipalities have begun to directly invest in constructing broadband infrastructure, just as cities build schools, pave roads, and construct hospitals.[9] Justification for such construction is nearly always tied to the pro-growth potential of broadband services, and frequently tied to the failure of private firms to provide adequate broadband services, if any at all, to the community.[10]

In this paper, we explore whether direct municipal broadband investment in broadband infrastructure creates positive economic gains for the community as a whole. Theoretical research suggests it might, particularly in economically disadvantaged communities.[11] It has been argued that municipalities invest in broadband infrastructure to serve a diffuse "public purpose" (better educated public, more business opportunities, etc.) that private communications providers acting alone may ignore since these external benefits cannot be captured as profits. The Bureau of Economic Advisors estimates that for each $1 invested in broadband, the economy benefits nearly $3 – but unless a private communications provider can gain the lion's share of that economic benefit, its incentive will be to under-invest in broadband infrastructure.[12] Economic theory indicates that in the presence of large externalities, which broadband Internet probably produces, public ownership of resources may be desirable.[13] While there are a number of colloquial examples of communities that attract jobs or companies due to a

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8 Remarks of Michael J. Copps, Commissioner, Federal Communications Commission, FCBA Denver Chapter (Jan. 11, 2002) http://ftp.fcc.gov/Speeches/Copps/2002/spmjc202.html.

9 *See, e.g.*, FMEA, *The Case for Municipal Broadband in Florida (*March 2005) at 9 (describing project in Jacksonville, Florida in which municipal broadband network provides medical help to inner city, asthmatic children).

10 *See* UTOPIA White Paper at 9 ("Private enterprise has not deployed true broadband to homes and small businesses in a widespread way.").

11 See, e.g., R. Robinson, *Dependency, Government Revenue, and Economic Growth*, 12 STUDIES IN COMPARATIVE INTERNATIONAL DEVELOPMENT 3-28 (1977); P. Martin, *Public Policies, Regional Inequalities and Growth*, 73 JOURNAL OF PUBLIC ECONOMICS 85-97 (1999); P. Martin and C. A. Rogers, *Industrial Location and Public Infrastructure*, 39 Journal OF INTERNATIONAL ECONOMICS 335-362 (1995); and M. A. Hesham, M*ulti-firm City Versus Company Town: A Micro Foundation Model of Localization Economies*, 40 JOURNAL OF REGIONAL SCIENCE 755-771 (2000).

12 Bureau of Economic Analysis, *Input-Output Accounts Data: 1999 Annual I-O Table Two Digit, available at* http://www.bea.doc.gov/bea/dn2/I-ohtm#annual. A study funded by Verizon Communications points to numerous external benefits of broadband deployment. See R. W. Crandall and C. J. Jackson, *The $500 Billion Opportunity: The Potential Economic Benefit of Widespread Diffusion of Broadband Internet Access*, in Allan L. Shampine (ed) DOWN TO THE WIRE: STUDIES IN THE DIFFUSION AND REGULATION OF TELECOMMUNICATIONS TECHNOLOGIES, Nova Science Press, Haupaugge, NY (2003).

13 J. Vickers and G. Yarrow, *Economic Perspectives on Privatization*, 5 JOURNAL OF ECONOMIC PERSPECTIVES 111-132 (1991) ("In competitive market conditions (and in the absence of other market failures), externality effects are small, so private profit and social welfare objectives are closely aligned, and private governorship is likely to have the advantage []. On the other hand, public ownership may have the advantage if externalities are larger (at 114))."

municipal broadband network, in this paper, we utilize an econometric model to test this hypothesis.[14]

To study the economic effect of municipal broadband on economic growth, we use an econometric model to compare economic growth in Lake County, Florida, with other similar Florida counties. In 2001, Lake County – a small, central Florida county of nearly 250,000 residents and 953 square miles – began offering private businesses access to one of Florida's most extensive, municipally-owned broadband networks, with fiber optic connections to hospitals, doctor offices, private businesses, and 44 schools.[15] *Our study shows that Lake County has experienced approximately 100% greater growth in economic activity relative to comparable Florida counties since making its municipal broadband network generally available to businesses in the county.*

Our findings provide support for the position that municipal broadband infrastructure may better serve the overall community than simply relying solely on private telecommunications firms. This is not to say that private firms do not provide quality service – indeed, the Lake County municipal system was constructed by private companies, the system leases capacity to private network providers, and customers use the system to supplement services from other providers (for example, Lake-Sumter Community College uses the municipal fiber network to deliver its educational television station to the local cable television company). But our analysis shows that since 2001, when the network was launched, Lake County has experienced a significant and sustained burst of economic activity relative to its peers, all of which have at least some private investment in broadband network. As a result, efforts to restrict municipal investment in broadband stand the risk of removing a significant and substantial tool for cities and towns that want to grow their economies and develop their communities.

II. Summary of Methods and Findings

In this study, we quantify the effect on economic development resulting from a community's investment in a broadband network. One difficulty in doing so is the general lack of sufficient economic and demographic data to analyze changes in a community's economic fortunes. Broadband service is a relatively recent phenomenon, and local economic data is often not collected on a regular basis for a detailed econometric analysis. However, in Lake County, Florida, we were able to find sufficient information on economic activity both before and after the deployment of municipal

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14 For example, Munn's Air Conditioning and Heating, headquartered in Lake County, Florida, credits the municipal fiber network in that county for its ability to expand: "Recently, we expanded our businesses to new markets farther away from our 'base' here in Fruitland Park [Fla.]. The ease of this expansion is largely due to the Fiber Network the City has had the presence of mind to build." Letter from Charles Thompson, Munn's Air, to Ron Stock, City Manager, City of Leesburg, Florida, March 8, 2005 ("Munn's Letter").

15 The municipality began construction and use of the network in 1992, but its use was very limited.

broadband infrastructure. We use this data in an econometric model to quantify the effect of the municipally-owned broadband network on economic growth.

Our statistical procedure measures the impact of the municipal network on economic activity by comparing economic growth in the community with the municipal network to other communities with comparable economic growth patterns prior to the municipal broadband investment. We then compare post-broadband deployment economic performance between these counties. Put another way, say we observe that two communities are nearly identical in terms of economic growth over some specified period of time, responding similarly to general macroeconomic conditions (e.g., interest rates and trade). In a subsequent period of time, however, there is some "economic event" affecting only one of the two communities. In the period for which this economic event is relevant, we observe that these two communities have divergent economic growth rates. This difference in growth, then, is attributable to the "economic event" – in this case, the deployment of a municipal broadband network.

This comparison of economic growth across comparable communities is the basis for our econometric test of the impact of municipal broadband on economic development. Our community of interest is Lake County, Florida. We selected Lake County, Florida, as the subject of our study for a number of reasons. First, the City of Leesburg began offering its county-wide broadband network to local businesses and municipal agencies broadly in 2001, and its deployment is relatively more extensive than other projects in the state (the fiber network is county-wide and not confined to the city). Detailed data is also available. The Florida Department of Revenue provides month-by-month, county-by-county reports since January 1998 of retail sales data, which we utilize as a proxy for economic activity. As a result, we have three years of monthly retail sales data before Lake County's generally offering of its broadband network as well as nearly three years data after this expanded use of its network (excluding the expansion period 2001).

Moreover, Lake County is, in some ways, a rather typical Florida county. On the edge of the Orlando Metropolitan Statistical Area, Lake County contains some suburban and some rural areas but does not contain any major urban center (its population density is 220.9 per square mile, compared to Florida's overall density of 296.4). The 2000 census reported that Lake County's per capita income was slightly below Florida's average. Retail sales per capita have historically been below the state average ($7,781 in 1997, compared to $10,297 statewide). Advocates on both sides of the issue of municipal broadband entry routinely state their desire that non-urban localities like Lake County receive the same broadband options that downtown, urban residents may have.

To determine whether Lake County's broadband investment boosted its economic performance since 2001, we selected a group of comparable counties in Florida so that an "apples-to-apples" comparison could be made. Our study compares Lake County's economic performance to a group of other similarly situated Florida counties, save the presence of a municipal broadband network.[16] A statistical methodology selects the

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[16] Comparable counties with municipal broadband networks are excluded from the control group.

"control group" of comparable Florida counties by determining which counties were experiencing an economic growth pattern most similar to Lake County prior to 2001, the year when Lake County launched its broadband network for general public use. We then examine whether Lake County's economic growth rate changed relative to these comparable counties after 2001, the period for which the county offered broadband services to local businesses and more broadly to municipal institutions.

The peer counties used in our analysis consists of ten different Florida counties that are very much similar to Lake County in terms of economic performance. These counties, listed in Appendix A, represent a cross-section of the state – from urban counties of Seminole and Broward to rural counties like Suwannee and Madison, to geographically-similar counties like Charlotte and Manatee. While these counties often differ in demographic profile (see Appendix A), their economic activity levels are highly correlated with Lake County and their economic growth rates are nearly identical over the period 1998 through 2000. We can use the economic performance of these counties since 2001 in comparison to Lake County to see whether Lake County has experienced a statistically significant change in economic growth versus these peers.[17]

The results of the test are strong. Relative to these comparable Florida counties, Lake County experienced a dramatic increase in economic growth after 2001. This economic growth is not simply a function of population growth, as we find a similar change if the data is expressed in levels or per-capita terms. Under either specification, Lake County's growth rate after 2001 has been roughly twice that of the control group (i.e., 100% higher). The growth rate differential is statistically significant, meaning that the difference in economic activity is well estimated and unlikely due to random variation in the data. So, while Lake County's growth rate and economic activity level was nearly identical to the control group prior to 2001, the county experienced a statistically and economically significant increase in growth after offering its municipal broadband network broadly to local businesses and government agencies. Such a large effect on economic growth suggests that public ownership of broadband infrastructure can contribute significantly to economic development, and that such investment may in fact be necessary if the private sector undersupplies broadband network infrastructure in a particular community.

III. Details of Methods and Findings

In this section, we describe the method and data we utilized to arrive at our findings. As discussed above, our interest is in whether or not municipal broadband projects impact the economic development of the municipality in which they are deployed. Economic growth is an obvious measure of economic development, so we begin with a simple

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[17] We perform this test both on the levels of the data as well as in per-capita terms, effectively rendering two tests of the growth rate differential.

model of economic growth.[18] Let y be a measure of economic activity. The formula for compound growth is

$$y_t = y_0(1+g)^t \tag{1}$$

where y_0 is the initial value of economic activity, g is the growth rate, and t is time. Taking the natural logarithm of both sides (and ignoring seasonality), Equation (1) can be expressed in econometric form as

$$\ln(y_t) = \beta_0 + \beta_1 t + \varepsilon \tag{2}$$

where $\beta_0 = \ln(y_0)$, $\beta_1 = \ln(1+g)$, and ε is the econometric disturbance term. The coefficient β_1 measures the instantaneous rate of growth in economic activity; the compound rate of growth is $[\exp(\beta_1) - 1]$. The starting level of y is simply $y_0 = \exp(\beta_0)$. In Equation (2), β_1 is assumed to be constant over t.[19]

This simple growth model can be expanded to measure the marginal impact on growth of a change in the productive capacity of an economy occurring during the period T*. Say there are two economies of interest, A and B, which have the same growth rate in period T (which is prior to period T*). The growth rate equations in T are simply

$$\ln(y_t^A) = \beta_0^A + \beta_1 t + \mu \tag{3a}$$

$$\ln(y_t^B) = \beta_0^B + \beta_2 t + \nu \tag{3b}$$

where $\beta_1 = \beta_2$ but β_0^A may or may not equal β_0^B.[20] Assume, however, that in time period T* a new, growth-stimulating technology is deployed in economy B. In period T*, we have the two growth equations

$$\ln(y_t^A) = b_0^A + b_1 t + \mu' \tag{4a}$$

$$\ln(y_t^B) = b_0^B + b_2 t + \nu' \tag{4b}$$

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18 An alternative approach would be to specify a structural model economic activity; such models generally are multi-equation systems. However, we do not have the data required for such a model, and even if we did, we would run the risk of masking the effects of the broadband network, since many of the regressors in such a model are also indicators of economic activity (e.g., the size of the labor force and investment expenditures). See, e.g., G. Feder, *On Exports and Economic Growth*, 12 JOURNAL OF DEVELOPMENT ECONOMICS 59-73 (1983) and R. Ram, *Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time Series Data*, 76 AMERICAN ECONOMIC REVIEW 191-203 (1986).

19 Equation (2) can be extended to allow for intertemporal variation in growth rates.

20 If the economies differ in the level of y, then the coefficients will be different.

where no particular relationships between b_i and β_i are assumed (the latter from Equations 3a and 3b). If the technology positively impacts growth, then we have $b_2 > b_1$ (i.e., growth is higher in economy B). If the technology has no effect on growth, then we have $b_2 = b_1$. While it is unlikely that a new technology will reduce growth, a reduction in growth renders $b_2 < b_1$. From both a directional and size perspective, the marginal contribution to growth of the new technology is measured by $b_2 - b_1$, with the percentage change being equal to $(b_2 - b_1)/ b_1$.

Note that comparing b_2 to β_1 (measuring the temporal change in growth) does not indicate the contribution of the technology to growth, since general economic conditions may alter the growth rates between periods (b_1, the growth rate absent the technology, may not equal β_1). The impact of the technology can only be assessed (in this model) by comparing the economic growth rate of the technology-affected economy B to growth in the unaffected, but otherwise identical, economy A. The need to focus on relative growth is a requirement of the model, because we are comparing the economic performance of one community (Lake County, Florida) with its peers (other Florida counties). We chose this method given the limitations in available data and the nature of the question at hand.

1. Estimation Procedures

With data on y^A and y^B, the parameters β_0, β_1, b_0, b_1, and b_2 can all be estimated using appropriate econometric techniques, thereby quantifying of the marginal impact of the technology on economic growth. In this study, we are using county level data, so the "economies" in the empirical model are "counties."

Our framework could be utilized to measure the economic significance of any particular event or technology (if sufficient data were available). Of concern to us is the availability of a municipal-owned broadband infrastructure. Our empirical framework assumes that the two economies, A and B, are nearly identical in the pre-technology period T. So, we need to select a group of counties to represent the "A" economy; Lake County is the "B" economy. From a theoretical perspective, the members of this "control group" should have two relationships to Lake County in period T: 1) the growth rates (β_1 and β_2) should be equal and 2) the economic activity levels should be highly correlated [that is, a high correlation coefficient between y or $\ln(y)$].[21] Equality of growth rates satisfies Equations (3a) and (3b), while the high correlation among counties ensures that control group economies behave nearly identically over time.[22] So, while

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[21] The correlation coefficient is a measure of the degree of association between two series of numbers. The correlation coefficient always lies between 1.0 (moving perfectly together) and -1.0 (moving perfectly inversely to one another). A correlation of zero means that there is no tendency of the series to move together.

[22] It is possible that identical growth rates could arise from economies that behave very differently over time. For example, growth in Lake and Franklin counties are very close (0.0080 and 0.0085), but their correlation coefficient is very small (0.165). The ρ constraint ensures the selection of only very similar economies by adding an additional dimension of likeness. Grouping markets or economies by evaluating

there are different demographic and business profiles among the counties, these differences do not lead to systematic differences in the observed growth and economic activity among the counties.[23] If both statistical criteria are met, the qualifying county economies will be nearly identical in their economic activity levels over the time period, which is necessary from a theoretical perspective given the chosen model.

Data

With the theoretical model in mind, our empirical approach proceeds as follows. First, we collect county-level data on *gross sales*, which is made available online by the Florida Department of Revenue on a monthly basis for the months Jan-98 through Nov-04.[24] "Gross sales" is a common measure of economic activity, and we use gross sales in this study as the dependent variable of the regression analysis (y).[25]

We define the two periods as follows: a) T is Jan-98 through Dec-00 and b) T* is Jan-02 through Nov-04. We exclude the transition year 2001, which is the year the municipal network in Lake County was first used widely to offer broadband services to local businesses over its municipal network. Exclusion of the transition year is common practice in "event" studies such as this one, since it allows for greater temporal separation between the two periods (T and T*) and avoids temporal instabilities.[26] Creating a time gap between the two periods also helps minimize any time dependence between the two periods, rendering better estimates of the effects of interest. Further, our statistical analysis reveals that the annual growth rates within T and T*, as defined, are generally equal; we are unable to reject equality of the annual growth rates for years 1998, 1999 and 2000 (period T), and for the years 2002, 2003, and 2004 (period T*). Annual growth in 2001, however, differs from the growth rates in both periods.[27] So,

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correlations of particular variables across markets and economies is used in a variety of contexts. See, e.g., an application to antitrust market definition in G. J. Stigler and R. A. Sherwin, *The Extent of a Market*, 28 JOURNAL OF LAW AND ECONOMICS 555-585 (1985).

[23] In fact, diversity in demographic and business profiles of the control group may provide us more robust and general conclusions as to the economic impact of the new technology. For instance, a subject county and control group of only rural counties would, at best, only be able to support a conclusion that the technology would benefit rural communities.

[24] http://www.myflorida.com/dor/taxes/distributions.html.

[25] According to the Center for Economic and Business Research ("CEBR") at the University of South Florida, this data on Gross Sales "is intended as a measure of economic activity (cedr.coba.usf.edu)."

[26] See, e.g., T. G. Andersen, T. Bollerslev and A. Das. *Variance-ratio Statistics and High-frequency Data: Testing for Changes in Intraday Volatility Patterns*, 56 THE JOURNAL OF FINANCE 305-327 (2001); R.W. Fairlie, *Drug Dealing and Legitimate Self-Employment*, 20 JOURNAL OF LABOR ECONOMICS 538-567 (2002); and P. Ralle and J. Tonjas-Bernatte, *Indexation des Salaires; la Rupture de 1983*, 92/93 ECONOMIE ET PRÉVISIÓN 187-19 (1990).

[27] This test is conducted using a homogenous growth rate for all counties that is estimated uniquely for each year. Equality is then evaluated using the Wald test.

excluding 2001 is necessary to ensure homogeneity of growth rates within the two periods.[28]

Selection of Peer Florida Counties

As a second step, we use a statistical test to select a group of Florida counties to which we compare Lake County. This group of peer counties represent the "A" economy of our empirical model, which we call the *control group*). This stratified sample is selected by first estimating (by ordinarily least squares) the growth rate (g_i) of sales (y_i) for *each* of the 67 counties in Florida over the period Jan-98 through Dec-00 (period T) using the equation

$$\ln(y) = \beta_0 + \beta_1 t + \sum_{m=1}^{11} \lambda_m M + \varepsilon, \tag{5}$$

where M_m are m monthly dummy variables, each having a unique coefficient λ_m (i.e., the seasonality effects). There are 11 (m) monthly dummy variables, with December being excluded to avoid the dummy trap. Next, we compute the simple correlation coefficients (ρ_i) of $\ln(y)$ between Lake County and each of the other 66 counties.

For selecting the control group of counties, we employ a simple two-factor, joint selection rule: 1) choose counties with a growth rate g_i within the 80% confidence interval of Lake County's growth rate and 2) choose counties with $\rho_i > 0.80$.[29] Both criteria must be satisfied for a county to qualify for the control group. The symmetric boundary around Lake County's growth should produce a mean (and median) growth rate for the control group (statistically) equal to the growth rate for Lake County, and statistical equality between Lake County and the others individually (with an acceptable degree of statistical confidence).[30] This procedure renders twelve comparable counties, five of which have municipal networks that provide at least some broadband services over (some part) the time period analyzed.[31] So, we exclude these counties. The final

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[28] Equality cannot be rejected for the per-capita data, but including 2001 does not materially alter the results. For consistency, we exclude 2001 from the analysis using per-capita data. Including 2001 from the level data does not impact much the size of the difference.

[29] These boundaries were chosen so that a reasonably large group of comparables could be constructed. Increasing (decreasing) either of the thresholds will reduce (increase) the number of comparable counties. Generating a very large group of comparables runs the risk of having unlike counties in the control group, so the goal is to keep the thresholds "tight" (i.e., a small confidence interval around g and ρ values close to 1.0).

[30] The Wald test indicates that the growth rates in all the counties are statistically equal (F = 1.15, Prob = 0.33), and the test also reveals the growth rate in Lake County is not different from that of the mean or median of the control group.

[31] Based on the APPA ANNUAL DIRECTORY AND STATISTICAL REPORT (2005).

panel contains eight counties (Lake plus seven comparable counties). The counties, along with relevant descriptive statistics, are listed in Table 1.

Table 1. Members of the Panel Dataset

County	g_i	ρ_i	DW_i		PP_i	
			T	T*	T	T*
Lake	0.0080	1.00	1.11	1.88	-3.85	-15.07
Broward	0.0088	0.90	1.75	1.84	-5.33	-57.18
Charlotte	0.0072	0.84	1.76	1.81	-3.11	-13.91
Madison	0.0078	0.84	2.25	1.57	-5.68	-9.28
Palm Beach	0.0085	0.89	1.44	1.83	-4.28	-38.67
Sarasota	0.0072	0.90	1.40	1.73	-4.44	-5.64
Seminole	0.0077	0.82	1.79	1.93	-6.26	-11.73
Suwannee	0.0074	0.90	2.02	1.80	-5.42	-4.25
Average (exc. Lake)	0.0078	0.87	…	…	…	…

The data used in this study is time series data, and the particular properties of time series data can affect the quality of the estimated coefficients. We are concerned primarily with the presence or absence of serial correlation and stationarity.[32] In the presence of serial correlation, the estimated coefficients of the model will be unbiased and consistent, but inefficient. Non-stationary data could lead to spurious results, which are highly undesirable.[33]

We address both issues with appropriate statistical tests. For serial correlation, we compute the Durbin-Watson statistic ("DW") for both the periods T and T*. Positive first-order serial correlation is indicated if the computed DW is less than 0.69. All the DW statistics exceed these values, so serial correlation is not a problem.[34] To evaluate the stationarity of the series, we apply the Phillips-Perron test ("PP") for a unit root.[35] The null hypothesis of the PP test is "y has a unit root," and the critical value is about -2.92 with rejection indicated if the PP statistic is smaller (more negative) than the critical value.[36] We can reject the null hypothesis of the PP test for all series in both periods (the

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32 D. Gujarati, BASIC ECONOMETRICS (1995) at 401, 710-24. A central concern with the application of the constant growth model used here is the potential for spurious results due to non-stationary data. Gujarati at 1719.

33 See. e.g., Gujarati 710-24 and C. W. J. Granger, EMPIRICAL MODELING IN ECONOMICS: SPECIFICATION AND EVALUATION (1999).

34 The regressors influence the size of the computed DW statistic, and the use of the time-trend as the explanatory variable will push the value of DW toward 0. Since the time-trend is the only explanatory variable, the lower bound of the DW statistic (often called d_l) is the appropriate critical value for the test of serial correlation (thereby ignoring the typical indeterminate zone of the DW statistic). For details, see R. S. Pindyck and D. L. Rubinfeld, ECONOMETRIC MODELS & ECONOMIC FORECASTS (1991) at 144.

35 The Phillips-Perron unit root test is robust to serial correlation. Since we are testing for serial correlation, it seems appropriate to employ a test that renders reliable results regardless of the outcome of the DW test.

36 We also performed a battery of panel unit root tests on the entire panel, and these test all indicated stationarity.

PP statistics are less than the critical values), so we conclude our y series are stationary and, consequently, that our findings are not the result of spurious regression.

The summary information in Table 2 illustrates that we have selected excellent candidates for the control group – the growth rates for the control counties are practically and statistically identical to Lake County (0.008 versus 0.0078, on average) and the ln(y) series are highly correlated (0.87, on average). None of the series is serially correlated and each is stationary. For the period Jan-98 through Dec-00, the behaviors of gross sales over time for the panel of counties are nearly identical, thereby satisfying the principal assumptions of the empirical growth model.

2. ESTIMATION AND RESULTS

With our control group in place, we now turn to the estimation of Equations (4a) and (4b). We can estimate the relevant parameters and test for differences in growth rates by jointly estimating eight equations, one for each county in the panel, with each having the general form:

$$\ln(y_{it}) = (b_0 + a_i) + b_1 t + \delta d \cdot t + \sum_{m=1}^{11} \lambda_{mi} M_{mt} + \varepsilon_{it} \tag{6}$$

where b_0 is a common intercept, a_i is a fixed effect for county i, M_m are m monthly dummy variables, and d equals 1 for Lake County (0 otherwise). Seasonal effects are unique to each county, but b_1 is assumed to be equal across the control group counties. Growth for Lake County is $b_1 + \delta$; note that $b_2 = b_1 + \delta$ (from Equations 4a and 4b). The hypothesis test $\delta = 0$ is a direct test for the statistical significance of a change in the growth rate for Lake County in the T* period. Since we expect the disturbance terms (ε) to be correlated across the counties, all equations are estimated jointly using Seemingly Unrelated Regressions ("SUR").[37] Standard errors are estimated using the Panel Corrected Standard Error methodology.[38] We also bootstrap the critical values, since SUR has been shown in some cases to understate the estimated standard errors.[39] Our bootstrap procedure is the percentile-t method.[40]

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[37] A. Zellner, *An Efficient Method for Estimating Seemingly Unrelated Regressions and Tests for Aggregate Bias*, 57 JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION 348–368 (1962) and Zellner, A. (1963), *Estimators for Seemingly Unrelated Regressions: Some Exact Finite Sample Results*, 58 JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION 977–992 (1962).

[38] N. Beck and J. N. Katz, *What to Do (And not to Do) with Time series Cross-Section Data*, 89 AMERICAN POLITICAL SCIENCE REVIEW 634-647 (1995).

[39] P. Rilstone and M. Veall, *Using Bootstrapped Confidence Intervals for Improved Inferences with Seemingly Unrelated Regression Equations*, 12 ECONOMETRIC THEORY 569-80 (1996).

[40] *Id*. We use 999 simulations and choose the 0.05(999+1)/2 and 0.095(999+1)/2 quantiles of the sorted statistics as critical values (i.e., the statistics associated with the 5% significance level in a two-tailed test). J. G. MacKinnon, *Bootstrap Inference in Econometrics*, 35 CANADIAN JOURNAL OF ECONOMICS 615-645 (2002).

The results of the SUR estimation are summarized in Table 2. The coefficients for the fixed effects and monthly dummy variables are suppressed, since they add no useful information to our empirical inquiry. The null hypothesis of the Breusch-Pagan test -- "no correlation of the residuals" – is easily rejected, indicating that the residuals are correlated.[41] As for the estimates of interests, both b_1 and δ are statistically-significant at the 5% level or better in the two-tailed test, regardless of whether asymptotic or bootstrapped critical values are used.

Table 2. Summary of Regression Results

(Jan-02 through Nov-04)

	Coefficient	t-statistic	Bootstrap Crit. Value
b_1	0.00419	5.80*	2.84
δ	0.00424	7.63*	2.74
$b_2 = b_1 + \delta$	0.00843		
Obs.	35		
Members	8		
Panel Obs.	280		

* Statistically significant at the 5% or better.

This regression shows that the estimated economic growth rate since 2002 in Lake County (b_2) is more than 100% larger than the control group of Florida counties (b_1). The estimate of b_1 indicates that monthly economic growth in the relevant time period was about 0.419% per month for the control group, compared to the estimated growth rate for Lake County of 0.843% per month. The estimated coefficient δ, which measures the difference in growth between Lake and the control counties, is statistically significant and different from zero, which allows us to *reject* the hypothesis that the growth in Lake County remained equal to that of the control group counties in T*. Indeed, the positive and statistically significant coefficient on the coefficient δ is implies that Lake County experienced a positive and meaningful increase in economic growth since January 2002 in comparison to the other Florida counties in the control group. This finding is consistent with the hypothesis that Lake County's broadband network stimulated economic growth.

Per Capita Results

In order to test whether our results are the function of population growth in Lake County or the control group, we replicate the estimation algorithm using per-capita data (i.e., we divide y by county population). By expressing the data in per-capita terms, we account for the possibility that any difference between county sales growth was caused not by the municipal network but by an exogenous population change, such as the creation or expansion of a housing development, the closing of a military base, or some other population affecting event within the county. As an initial matter, we note that population growth in a county could, in fact, be a positive consequence of broadband

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[41] T. S. Breusch and A. R. Pagan, *The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics*, 47 REVIEW OF ECONOMIC STUDIES 239–254 (1980).

availability. To the extent Lake County's broadband network impacts the economy, it is also likely to impact population. In fact, population growth is often used as an index of economic development in empirical studies, so it is probably incorrect to assume that population growth is exogenous (independent) of the change we are interested in studying.[42]

Setting this concern aside, we felt it would be interesting and useful to repeat our analysis using per-capita data, dividing gross sales by total population in the county.[43] Expressing the data in per-capita terms assumes that population growth is not affected by the availability of the municipal broadband network. As a result, the analysis requires us to select again a control group based on per-capita data. This selection identifies a slightly different control group of Florida counties, but most of the members in the per-capita control group are also in our first control group.

Table 3. Members of the Panel Dataset, Per-Capita Data

County	g_i	ρ_i	DW_i		PP_i	
			T	T*	T	T*
Lake	0.0047	1.00	1.09	1.88	-4.97	-6.88
Charlotte	0.0052	0.84	1.78	1.81	-3.51	-4.44
Highlands	0.0040	0.85	2.05	2.11	-4.49	-4.24
Hillsborough	0.0038	0.85	1.22	1.36	-7.21	-6. 06
Manatee	0.0045	0.86	2.60	2.15	-6.05	-7.18
Sarasota	0.0055	0.90	1.40	1.72	-4.70	-5.91
Seminole	0.0054	0.82	1.79	1.93	-6.97	-6.94
Suwannee	0.0054	0.90	2.03	1.69	-6.30	-4.98
Average (exc. Lake)	0.0048	0.86	…	…	…	…

Panel members are listed in Table 3 along with the relevant descriptive statistics. As Table 3 shows, our control group selection rule again selects seven counties to compare against Lake County. By design, growth rates are similar and correlation coefficients are high.[44] Table 4 summarizes the estimated parameters of Equation (6) using per-capita data. Again, the null hypothesis of the Breusch-Pagan test is rejected, so the residuals of the regressions are correlated and SUR estimation is beneficial.

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42 See, e.g., G.A Carlino and E. S. Mills, *The Determinants of County Growth*, 27 JOURNAL OF REGIONAL SCIENCE 39-54 (1987) and S.C. Deller, T.H. Tsai, D.W. Marcouiller and D.B.K. English, *The Role of Amenities and Quality of Life in Rural Economic Growth*, 83 AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS 352-365 (2001).

43 The population data is annual, and we assume constant for all months in the year. Population data is from http://www.state.fl.us/edr/population.htm.

44 Growth in Lake County is not statistically different from the mean growth of the control group in period T.

Table 4. Summary of Regression Results, Per-Capita Data

(Jan-02 through Nov-04)

	Coefficient	t-statistic	Bootstrap Crit. Value
b_1	0.00222	3.07*	2.84
δ	0.00285	5.20*	2.72
$b_2 = b_1 + \delta$	0.00507		
Obs.	35		
Members	8		
Panel Obs.	280		

* Statistically significant at the 5% or better.

This per-capita regression renders similar results to the levels data – *since 2002, per-capita economic activity in Lake County grew at more than twice the rate (0.507% per month) of the control group of Florida counties (0.222% per month).* These results are statistically significant at the 5% level or better, so we can reject equal growth rates with a high degree of statistical confidence. (These monthl**y** growth rates are lower than the rates in Table 2 because population is growing.) As before, growth in Lake County is larger than growth in the control group counties; the δ coefficient indicates a 128% increase in relative growth. Since δ is statistically different from zero, we can reject again the null hypothesis that Lake County's growth was the same as the control group in period T*. This result implies that even if we assume all population growth is independent of the broadband network, Lake County experienced a higher growth rate since 2002 relative to the control group of comparable Florida counties. In other words, the higher economic growth we observe in Lake County since 2002 is not explained solely by relative population changes.

IV. Conclusion

The City of Leesburg has deployed an extensive, fiber-optic broadband network throughout Lake County, Florida. This project was a significant, multimillion-dollar project in a relatively small community. In 2001, the broadband network was offered broadly to businesses and government institutions with the intent that doing so would boost economic development in the county. It appears that that plan has succeeded, and county residents are apparently harvesting the fruits of this investment in broadband infrastructure. Our econometric model indicates that Lake County has experienced a 100% increase – a doubling – in economic growth relative to its Florida peer counties since offering its municipally owned broadband network broadly to public and private entities. This growth rate is not a function of population growth – indeed, on a per-capita basis, Lake County has experienced 128% growth over its peers since the municipal broadband network was built.

Our findings are consistent with other analyses postulating that broadband infrastructure can be a significant contributor to economic growth. The Bureau of Economic Advisors (along with others) has stated that broadband infrastructure confers positive, public benefits on the economy, and our results provide support for presence of large external benefits from communications networks.

It is important to understand that Lake County's peers no doubt had at least some private broadband network in their communities during the time period evaluated, but these privately-owned networks *did not* produce the sizeable growth of Lake County's municipal system. This difference may be the result of the difference in deployment incentives. A municipally-owned broadband infrastructure (like Lake County's) is generally built to fulfill the public benefit of broadband, rather than simply to increase the profits of private firms. It is reasonable, then, to hypothesize that private network providers, since they would not collect as profits all of the benefits that a community would reap from a broadband infrastructure, would not necessarily deploy infrastructure as extensively or pervasively.[45] Flexibility and better customer service may also contribute to differential impacts. Advocates of municipal broadband investment have stated, "municipalities owe a duty to maximize the economic development of the communities they serve" and that with regard to broadband and economic development, "the public and profit interests sufficient diverge to require action by the local government."[46] Perhaps the best witnesses are county businesses themselves: Munn's Air Conditioning & Heating, a Lake County business that used the municipal network to expand, noted, "the City has shown great foresight in establishing this network. No other entity … especially big corporate types … would 'belly up' to the need that has existed for easy and robust data communication."[47]

Moreover, our econometric model shows that efforts to restrict municipal broadband investment – as several bills pending before the 2005 Florida legislature and other states would do – could deny communities an important tool in promoting economic development. Municipalities build schools, roads, hospitals, parks, marinas and convention centers in order to attract businesses, jobs, and improve the quality life of their communities. Broadband investment is another form of infrastructure that could offer those and other community benefits. If further municipal investment is hindered or prohibited, the economic development boost Lake County seems to have received from its broadband investment would be denied to other communities.

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45 *See* FMEA, *The Case for Municipal Broadband in Florida* (March 2005) at 6-10 (which argues "broadband networks provide benefits that may not be recognized by the private sector").

46 *Id.* at 9-10.

47 Munn's Letter at 2.

Appendix A. Demographic Profile of Control Group Counties

Table A-1. Demographics of Control Group Counties

County	Control Group	Population, 2003 est.	Persons per square mile, 2000	Per capita income, 1999	Percent below poverty, 1999	Retail sales per capita, 1997
Lake		245,877	220.9	$20,199	9.6%	$7,781
Broward	1	1,731,347	1346.5	$23,170	11.5%	$12,174
Charlotte	1	153,392	204.2	$21,806	8.2%	$8,035
Highlands	2	91,051	85.0	$17,222	15.2	$8,239
Hillsborough	2	1,073,407	950.6	$21,812	12.5	$12,018
Manatee	2	286,804	356.3	$22,388	10.1	$9,110
Madison	1	18,766	27.1	$12,511	23.1%	$3,653
Palm Beach	1, 2	1,216,282	573.0	$28,801	9.9%	$11,561
Sarasota	1, 2	346,793	570.3	$28,326	7.8	$12,011
Seminole	1, 2	386,374	1184.9	$29,591	7.4%	$10,333
Suwannee	1, 2	36,695	50.7	$14,678	18.5%	$6,348
Florida		17,019,068	296.4	$21,557	12.5%	$10,297

Source: U.S. Census Bureau, State and County QuickFacts, http://quickfacts.census.gov