

The Economic Impact of Municipal Broadband*

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Abstract

This paper investigates the economic effects of this transformation on the MEUs themselves and on the local economy. It does so by testing three hypotheses: (i) the “Internal Efficiency Hypothesis”, which states deployment of IT-based solutions for system control and monitoring have a positive effect on MEU’s internal efficiency; (ii) the “Cross-Subsidy Hypothesis” which states that, everything else being equal, if MEUs subsidize their external broadband services with funds from their electric power operations, they should exhibit higher electricity prices and costs than MEUs that do not offer external broadband services; and (iii) the “Local Economic Development Hypothesis”, stating that deployment of external broadband services by MEUs is associated with positive effects on local economic development.

Testing these hypotheses helps to explain some opportunities and identify challenges presented by the deployment of advanced telecommunication services by MEUs, and to inform a policy debate that has been mostly based on anecdotal evidence or limited analysis.

Our empirical analysis of the Internal Efficiency Hypothesis reveals that MEUs that have adopted new generation IT-based systems for internal control and monitoring operations exhibit prices and costs for customer service, and sales and information per unit of output that are, respectively, 2% and 30% lower than for non-adopter MEUs.

The analysis of the Cross-Subsidy Hypothesis discusses the implications of our results for policy makers. There has been concern that MEUs may be subsidizing external broadband services with the proceeds of their electric services. Such practices would put them at a competitive advantage with telecommunications providers from the private sector and possibly raise electric rates. Insofar as our result indicates, this is not the case.

* This paper is adapted from the Econometric Analysis of the PhD Dissertation of the author “Functional Emergence and Architectural Innovations in Engineering Systems”. There are several references to the qualitative analysis, which is not included on this paper.

We also test the Local Economic Development Hypothesis. Our analysis shows that MEU-based broadband is associated with 1.56% increase in the growth rate of local business establishments between 2000 and 2002. If one considers MEUs that operate in markets with private broadband providers, this effect is 1.2% —smaller but still statistically significant. This result is relevant because it might be signal that private providers focus on private returns from investment lead them do underserve broadband markets. MEUs, however, focus also on the value created by competition, externalities and social impact. The section also discusses effects on the growth of business establishments specifically in the IT sector, employment levels, and salaries.

Testing these hypotheses helps to explain some opportunities and identify challenges presented by the deployment of advanced telecommunication services by MEUs, and to inform a policy debate that has been mostly based on anecdotal evidence, limited analysis, and advocacy perspectives. The hypotheses were tested using matched sample estimators (MSE), a method recently developed that can be used to calculate the average effect of technology deployments (Abadie, Drukker et al. 2001). Section 1 explains MSE's rationale in more detail.

Testing the IEH shows that MEUs that have adopted new generation IT-based systems for internal control and monitoring operations exhibit lower prices and costs for customer service, and sales and information per unit of output, but higher general expenses and administrative cost. Test of the CSH reveals no evidence of the existence of cross-subsidies from electric power to broadband operations. Finally, our analysis of LEDH indicates that deployment of MEU-based broadband by 2000 is associated with an increase in the growth rate of local business establishments between 2000 and 2002.

1 Research Design: Research Questions, Hypotheses and Method

The architectural evolution of MEUs should have had economic impacts within the organizations and in their localities. MEUs first deployed new generation networks to improve the management of their electric power operations. It should be possible to measure the effects of the new technology on MEUs' internal efficiency. Public decision makers have an increasing need for evidence about the impact of broadband services provided by municipal electric utilities. If MEU-based broadband does affect local economic development, one should be able to identify the impacts. An important policy question is whether MEUs provide cross-subsidies to their broadband services using funds from their electrical operations.

In this section we explain the research questions with their respective hypothesis, and the methods we use to answer those questions.

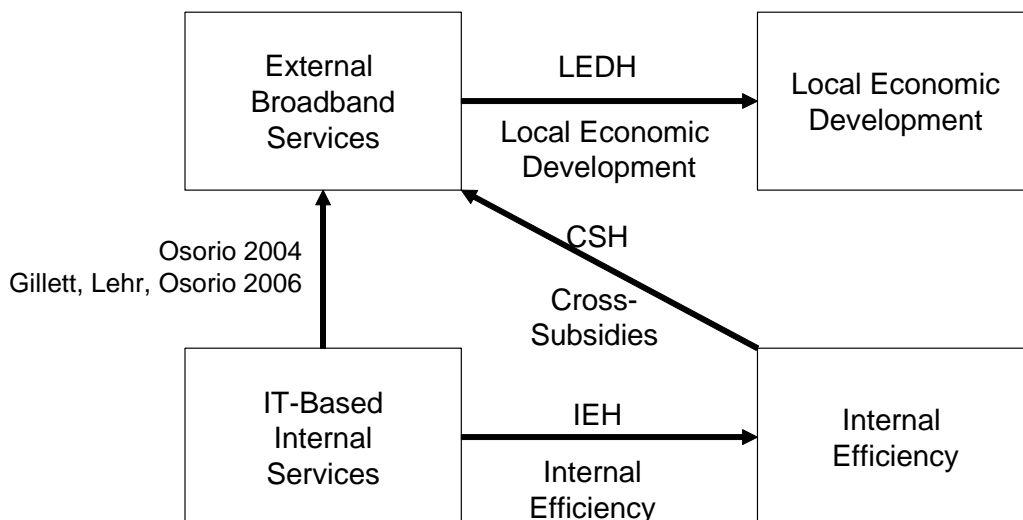
1.1 Research Questions and Hypotheses

Previous research has established the relationship between deploying network infrastructure for operating MEUs' internal control systems, and offering external telecommunication services by studying the factors affecting the likelihood of MEUs becoming providers of advanced telecommunications services (Osorio 2004; Gillett, Lehr et al. 2006). This relationship is explained in detail in Osorio (2006).

Here, we test three hypotheses. We examine whether the adoption of IP-enabled MEUs has enhanced the efficiency of their electric power operations testing what we call our Internal Efficiency Hypothesis (IEH). We also examine the existence of cross-subsidies from the electric power operations to MEUs' new broadband business, by testing our Cross-Subsidies Hypotheses (CSH). The issue of cross-subsidies is more complicated than this; in fact, they can flow *from* broadband to the electric power operations. MEUs could decide to partially fund their investments in internal IP-network infrastructure with their expected future broadband revenues. At this time, however, the lack of data does not allow for testing this hypothesis. Finally, we examine whether the deployment of external broadband services by MEUs has a positive effect on the local economy by testing the Local Economic Development Hypothesis (LEDH).

In this section explain each of these hypotheses, their overarching research question, rationale and the dependent variables we use to test them. **Figure 1** illustrates the relationship between previous research mentioned above, and ours.

Figure 1: Relationships among Hypotheses



Source: the author

- i. *What is the effect of the adoption of new IP-enabled SCADA and AMR on the internal efficiency of MEU?*

Answering this question would provide evidence of the impact of the original motive for the deployment of the technology and, from the perspective of efficiency in the use of public resources, the primary outcome we should expect to see. Previous work has suggested a link between IP-enabled SCADA and AMR and efficiency in electric power operations (IBM Business Consulting Services 2004; Black 2005), and this dissertation will examine it by testing its underlying hypothesis:

- Internal Efficiency Hypothesis (IEH): Everything else being equal, MEUs that have adopted IT-based control and monitoring systems for their Electric Utility operations exhibit higher levels of ex-post internal efficiency than non-adopter MEUs.

Here, our focus is to find whether the adoption of IP-enabled solutions for controlling and commanding electric power systems have had positive effects on their internal efficiency.

The hypothesis is tested using three different *dependent variables*: (i) price per mega watt-hour (MWh), (ii) customer service, sales, and information expenses per MWh, and (iii) administrative costs and general expenses per MWh.

- ii. *Do MEUs cross-subsidize their broadband services with revenues from their electric power operations?*

This question is subsidiary to the study of efficiency gains is a question with important implications for public policy. This question arises from concerns that MEUs could subsidize their broadband operations with revenues from their electric power operations, and drive private broadband providers out of business by offering lower prices. We answer this question by testing:

- Cross-Subsidy Hypothesis (CSH): If MEUs subsidize their broadband operations with funds from their electric power business then, everything else being equal, they will exhibit higher prices or costs in electric power operations than MEUs that do not deploy external broadband services.

The objective of this hypothesis is to study whether we can find evidence of statistically significant variations in price or costs of electric power operations for MEUs that become broadband providers.

The hypothesis is tested by looking at the effect between becoming an external broadband provider and the same three *dependent variables* as before.

iii. *What is the effect of the deployment of external broadband services by MEUs on the local economy?*

Answering this question will provide empirical evidence about either positive or negative effects. This analysis builds on the work of Lehr, Gillett, Osorio and Sirbu (2006) that suggested a positive relationship between the deployment of broadband and local economic development, and test the hypothesis underlying this research question.

- Local Economic Development Hypothesis (LEDH): Everything else being equal, towns where MEUs have deployed external broadband services exhibit higher levels of ex-post local economic development than towns without MEU-based broadband.

Our objective here is to study whether the deployment of external broadband services by MEUs is associated with positive effects on the local economy. This is done at two levels: (i) we analyze this relationship independently from the existence of private broadband providers, and (ii) we restrict our sample to study the existence of the same effect only among places with private provision of broadband.

The hypothesis is tested by looking at the effect of broadband deployed by MEUs using four *dependent variables*: (i) growth rate of local business establishments, (ii) share of business establishments in IT-intensive sectors, (iii) growth rate of employment, and (iv) growth rate of average salary, all measured for the period 2000-2002.

Each of these dependent variables is associated with different theories and assumptions about the effect of broadband on the economy. These theories are discussed in detail in Osorion (2006).

Having the research questions and their related hypotheses is the first step. In the next section we explain the method for testing them: Matched Panel Estimators.

1.2 Empirical Method: Randomized Control Trials and Matched Panel Estimator

From a methodological perspective, the problem of studying the effect of adopting or deploying a technology is similar to the problem of studying the effect of a medical treatment in a defined population.

In medical research, one first selects a random sample of the universe of interest. A treatment is randomly assigned to one group from the sample, forming a “treatment group”. A comparable sample will not receive the treatment, forming a “control group”. If the randomization is done properly, both groups are probabilistically similar, with the exception of receiving the treatment (Shadish, Cook et al. 2002). The researcher calculates the effect of the treatment by comparing the outcomes in the treatment and control groups.

This is called Randomized Control Trial (RCT), and is considered the most reliable scientific method for analyzing the effect of a “treatment” on a population.

In the case of our research, a RCT would require selecting MEUs and proceeding to randomly assign IT-based control systems to one group, and compare the effect of this on internal efficiency among treatment and control groups. Similarly, for the Local Economic Development hypothesis, it would be necessary to randomly assign a second group to become broadband providers, and analyze the effects on the local economies in which the MEUs are embedded. This type of analysis is practically impossible to implement in engineering systems.

The alternative is Matched Sample Estimators (MSE), also known as matched sample regression. MSE is a quasi-experimental method that emulates RCT, sharing many of its characteristics, with exception of random assignment (Campbell and Stanley 1963).

Abadie, Drukker, Herr, and Imbens (2001) developed MSE to measure the average effect of a treatment on a population or sample. Two groups of observations form the inputs: (i) one for which the treatment is available (i.e. MEUs that have adopted IT-based control systems), and (ii) another for which the treatment is not available (i.e. MEUs that have not adopted the technology). Each observation includes a vector of data that specifies the outcome (or dependent variable), the treatment, and a series of variables that will be used in the “matching process”. We used the implementation of MSE for Stata -Nmatch command- in our research.

In the “matching process”, the method pairs each observation of the treatment group with its closest match from the control group. The method includes an option for correcting for bias when the matching is not exact (Abadie, Drukker et al. 2001). By matching, the algorithm implemented in STATA emulates RCT by measuring the effect

of the treatment on the dependent variable among observations that would be identical if they were a perfect match¹.

This “*bias-corrected matching estimator*” adjusts the differences among matches using the differences on their covariates or matching discrepancies. It also allows for estimating heteroskedasticity-consistent standard errors (Kennedy 1998; Abadie, Drukker et al. 2001; Wooldridge 2003). In other words, it creates treatment and control groups that are as similar as possible.

Table 1 presents the dependent, treatment and matching variables used for the testing each hypothesis. The next section explains how the dataset was built. The matching criteria for testing the hypotheses are as follow:

- i. *Internal Efficiency and Cross-Subsidies Hypotheses*: observations are matched in terms of the size of the local market; availability of resources for funding the upgrade of infrastructure; basic characteristics of the utility; and lagged variables for the historical baseline of each dependent variable.
- ii. *Local Economic Development Hypothesis*: The matching process considers the size of the towns; their Urban-Rural Influence Code²; percentage of educated workforce; wealth; and lagged variables for the historical baseline of each dependent variable.

The use of MSE also offsets typical endogeneity problem associated with the deployment of infrastructure and the measurement of its economic effects (Holtz-Eaking and Schwartz 1994; Haltiwanger and Jarmin 2000). In our case, this means that the decision to deploy broadband is inevitably associated with the economic characteristics of the target market (Gabel and Kwan 2000; Prieger 2003; Flamm 2004; Grubestic 2004). MSE also corrects for this problem, and allows the estimation of robust standard errors.

Our choice for matched sample estimators is useful to policy makers because it enables comparison with previous results about the economic impact of broadband at a national level.

¹ See Stata help command Nnmatch.

² The Urban-Rural Influence code is developed by the Economic Research Service of the U.S. Department of Agriculture to proxy for the effect of population and proximity to large metropolitan areas as sources of economic opportunity of a locality.

Table 1: Hypotheses, Dependent Variables and Matching Variables

Hypothesis	Dependent Variables	Treatment	Matching Variables
Internal Efficiency Cross-Subsidies	<ul style="list-style-type: none"> price per mega watt-hour (MWh) 2003 customer service, sales and information expenses per MWh 2003 administrative costs and general expenses per MWh 2003 	<p><i>Internal Efficiency:</i> adoption of IP-enabled SCADA or AMR</p> <p><i>Cross-Subsidies:</i> deployment of external broadband services by 2000</p>	<ul style="list-style-type: none"> Customer Service, Sales and Information Expenses per MWh 2000 Revenue per MWh, 2000 Administrative and General Expenses per MWh 2000 Population 2000 % Purchase power 2000 % Steam power 2000 % Hydro power 2000 Income per Capita 2000 Medium Rent 2000
Local Economic Development	<ul style="list-style-type: none"> growth rate of local business establishments (2000-2002) share of business establishments in IT-intensive sectors 2002 growth rate of employment (2000-2002) growth rate of average salary (2000-2002) 	deployment of external broadband services by 2000	<ul style="list-style-type: none"> =1 if Private Broadband Providers 2000, 0= otherwise Growth Business Establishments 1994-1998 Growth Employment 1994-1998 Growth College Grads 90s Growth Average Salary 1994-1998 % Pop. Bachelor Graduate in 2000 % Establishments in IT-Intensive sectors 1998 Growth of IT-Intensive establishments 1998-2000 Growth Local Employment 1990-2000 Population 2000 Urban-Rural Influence Code

Source: the author

1.2.1 Functional Form for Measuring Growth Rates

Recent work using MSE has addressed the local economic impact of broadband in the United States at the zip code level (Lehr, Gillett et al. 2006). Based on their work, this analysis is performed using the following equation to study the external effect of the deployments by MEUs:

$$Y(t)=Y(0)^{\alpha}e^{rt}, \tag{1}$$

$$\text{where } r=r^*+\gamma \text{ treatment} +\mathbf{X}\boldsymbol{\beta}+e, \tag{2}$$

$$\text{thus } \ln(Y(t)/Y(0))=g(t)=a+\gamma \text{ treatment} +\mathbf{X}\boldsymbol{\beta}+e, \tag{3}$$

Where $a=\ln A+r^*=r^*$ if $A=1$, \mathbf{X} is a vector of control variables and $\boldsymbol{\beta}$ their estimators. Here, treatment represents whether the MEUs deployed external broadband. In the case of internal IT-based services we will use a typical linear regression model. Here, γ represents the estimated effect of the treatment on the dependent variable in period $[0,t]$, and e represents the error term.

2 Building the Database

For this study we have built a unique dataset which aggregates data about type of internal and external IT-based services by MEU, characteristics of their electric power operations, and economic, social and demographic data about the geographical areas where they are located, among others. This section presents the data sources. We also explain the process of building the dataset, with special emphasis on the solution of the problems of merging and aggregating data.

2.1.1 Data Sources

The most important data for this research was provided by the American Public Power Association (APPA). The dataset is drawn from the APPA annual member survey and includes information for all types of internal and external deployment of telecommunication services, including IT-based internal services and external broadband (**Table 2** summarizes the data sources). The APPA data provides the information required to construct the treatment variables for the analysis of the three hypotheses.

There are over 1,800 MEUs in the APPA dataset. The analyses, however, are performed over two sub-samples for which all data is available thus making possible a higher quality of matching. The first sub-sample, used to test the Internal Efficiency and Cross-Subsidy hypotheses, includes 421 cases; they constitute a representative sample of publicly-owned electric utilities as described by the Energy Information Administration (EIA)³.

Table 3 presents summary statistics and variable definitions for this case. The second sub-sample, used to test the Local Economic Development Hypothesis, includes 1,314 observations. **Table 5** presents summary statistics and variable definitions.

The dependent variables are taken from the Energy Information Administration's (EIA) Annual Electric Industry Financial Report, and the U.S. Census Bureau's Zip Code Business Patterns. The quality of EIA data is widely recognized, which has been called "*the primary source of financial and expense data for the public power sector, as well as plant cost data and transmission line information for all sectors except investor-owned utilities.*"⁴ The dependent variables were defined in section 1.

³ <http://www.eia.doe.gov/>

⁴ Comments of the American Public Power Association to FERC and Electric Energy Market Competition Interagency Taskforce, AD05-17-000, November 18, 2005. Last visited on March 21, 2006, see url at <http://www.appanet.org/files/PDFs/APPACmtsAD05-17.pdf>

Table 2.: Data Sources

Type of Data	Description	Availability	Source
Broadband and IT-based Internal Services	Internal and external telecommunication services by MEUs.	Collected once a year	American Public Power Association, 2000-2004
Private Broadband Providers	Providers of Digital Subscriber Line (DSL) and Cable Modem	Collected once a year	Warren (2004) and DSL data used in Gabel and Huang (2003)
Business Activity Indicators	Used to determine place level data on employment, business establishments, wages (payroll), industry sector and size mix.	Collected on annual basis. Most recent data from 2002. Coded by industry sectors using SIC (1994-7) and NAICS (1998-2002).	U.S. Census Bureau -ZIP Code Business Patterns (ZCBP) ⁵
Indicators of Internal Efficiency	Cost of operation and maintenance, cost of distribution, revenue and profits per MWh sold	Collected annually, from 1990 up to 2004.	Energy Information Administration forms 861 ⁶ , and 412 ⁷ .
Demographic Indicators	Place-level data for income, rent, educational attainment, and # of households.	Collected every 10 years; most recent data from 2000.	(1) U.S. Census Bureau - 2000 Decennial Census (2) GeoLytics – CensusCD (“1990 Long form in 2000 boundaries”) ⁸
Geographic Indicators	Used to indicate how urban or rural a county is, based on its population and proximity to metropolitan areas.	Computed every 10 years; most recent coding from 2003.	Economic Research Service, U.S. Department of Agriculture - Urban Influence Code (UIC) ⁹

As mentioned above, the matching sample estimators assess the effect of the “treatment” by comparing entities that are otherwise similar. The similarity is established by a matching process. The criteria for matching are explained in the following sections, and **Tables 3** (see section 4) and **5** (see section 5) exhibit all matching variables.

2.1.2 Merging Datasets and Aggregating Data

As our analysis is done at the MEU and place level, we faced the problem of merging databases at different levels of aggregation. Before performing the analysis we needed to merge various datasets, and clean and prepare the data. Appendix 6 includes the 8,663 lines of code that clean the original data, rename variables, merge the different

⁵ See http://www.census.gov/epcd/www/zbp_base.html

⁶ See <http://www.eia.doe.gov/cneaf/electricity/page/eia861.html>

⁷ See <http://www.eia.doe.gov/cneaf/electricity/page/eia412.html>

⁸ See <http://www.census.gov/main/www/cen2000.html> for data from the US Census Bureau, and for GeoLytics <http://www.geolytics.com/USCensus,Census-1990-Long-Form-2000-Boundaries,Products.asp>.

⁹ See <http://www.ers.usda.gov/Data/UrbanInfluenceCodes/>

datasets, and prepare the data for regression analysis. This code is built so one can access all datasets in their original state and build the one used to perform the analysis.

In the case of MEUs, the data was merged using datasets from the Energy Information Administration using the “Utility Code”, which is a unique identifier for all electric utilities. Each MEU is also associated with a town or city. Here, we use the term “place” to denote towns and cities following the description of the U.S. Census Bureau. Besides merging the APPA data with information from EIA, we merged datasets from the 1990 and 2000 Decennial Population Census. We used a unique identifier -AreaKey- to merge the Census data across places, and then the name of the place to merge the 1990 and 2000 Census data with the utility data. In some cases, the matching between MEUs and places required individual revision and correction. In such cases, these corrections are included in the code individually.

The analysis about the effect of broadband deployment on local economic development required the aggregation of raw data from the U.S. Census Zip Code Business Patterns to the place level. Aggregating data from zip code to place level, however, first required the aggregation of data from enclosed to enclosing zip codes. An enclosing zip code is a regular zip code with a defined geographical area, such as 02139 for Cambridge, MA. An enclosed zip code is also referred to as a “point” zip code, or one assigned to a large firm or specific building.

The problem arises because, while enclosed zip codes are physically located in areas represented by enclosing zip codes, their business statistics are presented separately. Failure to aggregate them would underestimate the count of business establishments, employment, and average salary, especially in dense urban areas where they are more common.

Thus, we first aggregated the data rolling up zip codes to represent business pattern statistics at the level of enclosing zip codes. Then, we aggregated data from zip code to place level. We did this by using the Census 2000 U.S. Gazetteer files¹⁰, which present subdivisions for states, counties, places, and Zip Code Tabulation Areas (ZCTAs). Aggregating the Zip Code Business Patterns with data at the place level required us to resolve an additional issue: while Zip Code Business Patterns are presented using U.S. Postal Service (USPS) zip codes, the Gazetteer files use ZCTAs.

ZCTAs are a representation of USPS zip codes created by the U.S. Census Bureau for the purposes of the Decennial Census. While, in most cases, a ZCTA will coincide with a zip code, there are exceptions. Some of these exceptions are the enclosed zip codes

¹⁰ For more information see <http://www.census.gov/geo/www/gazetteer/gazette.html>

mentioned above. Once we had the aggregation between enclosed and enclosing zip codes, it was possible to match USPS zip codes with ZCTAs. When the dataset was indexed by ZCTAs¹¹, we then aggregated the data to the place level, adding it up by ZCTAs.

As we merged and aggregated all data, we needed to confirm the names of places, counties, states, and add variables such as Rural Urban Influence Code. In many cases, these changes required writing extensive code for verifying and changing names. It should be noted that the process of matching entries for building the database is different from the process used in Matched Sample Estimators.

Sections 4, 5 and 6 present the results from matched sample regression and discuss the shortcomings of the analyses, and present further directions for research.

3 Economic Effect of IP-Enabled SCADA and AMR on MEU Internal Efficiency

We test the Internal Efficiency hypothesis by studying the effect of the new internal IP-enabled services on various measures of internal efficiency: (i) price, (ii) customer service, support, and information cost, and (iii) administrative costs and general expenses. All price and costs variables are measured by unit of output in megawatt hours (MWh). The latest available data is for year 2003¹².

For the purpose of this research, an MEU is considered to have internal IT-based, or IP-enabled, services if it had deployed technology for running either System Control and Data Acquisition (SCADA) or Automatic Meter Reading (AMR) by 2000. Some MEUs have also deployed two additional internal services: internal voice services and municipal data networks. However, only three out of the 421 cases offered internal voice and municipal data networks without running SCADA and AMR, and none by 2000. **Table 3** presents description and summary statistics for the dependent variables and variables used for matching among MEUs.

For testing the internal efficiency hypothesis, we matched the MEUs in three dimensions for the year 2000:

- (i) *size of the local market*: The proxy for “size” is the local population.

¹¹ For more information see <http://www.census.gov/geo/ZCTA/zcta.html>

¹² See <http://www.eia.doe.gov/cneaf/electricity/page/eia412.html>. The EIA has temporarily suspended the collection of this information.

- (ii) *availability of resources for funding the upgrade of infrastructure:* Income per capita and median housing rent are used as proxies to measure community wealth, the source of tax-based funds available to a municipal government. This is relevant because municipal electric utilities' investment decisions are often approved by the municipal council.
- (iii) *basic characteristics of the utility.* Utilities are considered similar based on the percentage of their power that is purchased, or generated through steam or hydroelectric power. The underlying assumption is that similarities in the technology will be associated with similarities in their human capital.

Table 3: Summary Statistics: variables for testing Internal Efficiency Hypothesis

Variables		MEUs		
Description	Name	Sub Sample	IT-based Internal Service	No IT-based Internal Service
		N=421	N=82	N=339
Price per MWh, 2003	PMwh03	66.58 (16.91)	67.14 (15.60)	66.45 (17.23)
Customer Service, Sales and Information Expenses per MWh 2003	CSSle03	36.36 (511.73)	0.35 (0.55)	0.33 (0.77)
Administrative and General Expenses per MWh 2003	S_Adm03	9.65 (102.77)	30.91 (232.55)	4.51 (5.43)
Treatment: =1 if IT-Based internal service, 2000	MEU_Int2K	19.43 (36.61)	1 (0)	0 (0)
Variables for Matching				
Customer Service, Sales and Information Expenses per MWh 2000	CSSle2K	0.18 (3.57)	0.33 (0.50)	0.14 (3.97)
Revenue per MWh, 2000	RMwh2K	64.35 (16.69)	65.76 (16.46)	64.01 (16.75)
Administrative and General Expenses per MWh 2000	S_Adm2K	4.03 (4.49)	4.62 (3.98)	3.89 (4.61)
Population 2000	Pop2K	59,833 (21,6252)	58,793 (90,533)	60,077 (23,6372)
% Purchase power 2000	Purpower2K	87.11 (24.67)	78.22 (31.48)	89.28 (22.23)
% Steam power 2000	Steam2K	9.07 (21.52)	17.58 (29.60)	7.00 (18.51)
% Hydro power 2000	Hydro2K	0.50 (5.11)	0.49 (2.01)	0.51 (5.61)
Income per Capita 2000	IncPC2K	18,929 (4,887)	19,576 (5,361)	18,777 (4,765)
Medium Rent 2000	Rent2K	509 (138)	541 (131)	501 (139)

Results from our matched sample estimators analysis show evidence that investing in new generation SCADA and AMR by 2000 is associated with increasing efficiency in

MEUs' internal operations by 2003 (See **Table 4**, column A). The analysis tests this relationship by considering various dimensions: (i) effect on cost of producing electric power, and (ii) effect on price of electric power by 2003.

Gains in efficiency--lower price and lower costs for information, and customer service and support--are accompanied by higher administration costs and general expenditures (ACGE). The analysis of matched sample estimation results suggests that investment in these solutions is associated with costs for customer service, support, and information management that are 30% lower than those of non-adopter MEUs. Furthermore, our analysis of the effect of such technologies on the price of electric power suggests that MEUs that have adopted IP-enabled systems exhibit lower prices than non-adopters. Sections 4.1 and 4.2 show more detailed analysis.¹³ Evidence from field research suggests that this increase in cost resulted from the hiring of more experienced and expensive senior management, and technical managers with experience in telecommunications.

Table 4: Internal Efficiency: Summary Results

Dependent Variable (2003)	Treatment: Adoption of IT-Based Internal Services by 2000 (A) Full Sample Estimated Magnitude	Treatment: Adoption of IT-Based Internal Services, given that broadband provider by 2000 (B) Sub-sample Estimated Magnitude	Treatment: External Broadband by 2000, given that Adopted IT-Based Internal Services (C) Sub-sample Estimated Magnitude
Price per MWh	-1.5420*	-3.6748**	0.9424
Customer Service, Sales and Info Expenses per MWh	-0.3573***	-1.4411***	-0.0080
Administrative costs and general expenses per MWh	19.9357**	0.9967*	-28.064
No. of Observations	421	44	76

Source: *: Statistically significant at 10% confidence level, **: Statistically significant at 5% confidence level, ***: Statistically significant at 1% confidence level.

¹³ Increases in overall efficiency are consistent with the literature on the effect of IP-enabled SCADA and AMR electric power (Tamarkin 1992, Johnston 2003, IBM Business Consulting Services 2004, Black 2005) and on the effect of information technology on productivity (Brynjolfsson, Hitt, et al. 2002, Stiroh 2002).

3.1 *Cost Efficiency per Unit of Output (MWh)*

Municipal electric utilities were matched according to the size of local markets (population in 2000), income per capita, average rent values, the percentage of purchased power, and percentage of generation from steam and hydroelectric power in 2000.

i. Effect on Customer Service, Support and Information Costs:

The association of IT-based internal systems with lower costs for information, customer service and support makes perfect sense from the perspective of the objectives of SCADA and AMR solutions: they are designed to diminish the costs of acquiring information, remote monitoring of substations and customer premises, and electric power consumption. Also, they require lower maintenance costs, slows down the obsolescence of the electric power infrastructure, and lower costs due to failures. The small size of the average MEU town in some cases make it possible to deploy Passive Optical Networks (PON), creating more robust and less expensive networks.

The average reduction of almost \$0.36 per MWh (1 [A]¹⁴) represents annual average savings of more than \$77,000 for these MEUs. This value represents a 1.44% reduction from costs not directly related to the purchase of fuel, power, and major capital expenses.

ii. Administrative Costs and General Expenses

Our results show that the adoption of new generation SCADA and AMR by MEUs before 2000 is associated with administrative costs and general expenses (ACGE) in 2003 that, on average, are \$19.9 per MWh higher than for MEUs that have not adopted such solutions (2[A]). Between 2000 and 2003, the average ACGE per employee increased by around 21% for MEUs without internal IT-based systems, but by approximately 33% for MEUs with internal IT-based services.

Detailed results are presented in the **Appendix**. There are two reasons for this: more expensive senior management and costs associated with the learning process. Additional analysis shows that (i) this increase in cost is associated with the deployment of IP-enabled communications infrastructure, rather than deployment of broadband services, and (ii) this increase in cost represents an opportunity for additional economies of scope.

¹⁴ These references point to the respective table in the Appendices in the following way: 1(A) means Table A at Appendix 1.

Evidence from fieldwork research and the COIREM analysis has shown that the first-adopter MEUs have been able to retain their linemen and technical staff and train them in very complicated tasks, but have to hire new, and in some cases a different type of, executives and department heads. These have been executives and technical professionals who bring experience in telecommunications, networks deployments, or fiber optics networks and new leadership as well. These employees command higher salaries than their predecessors.

These MEUs may also have invested in some capital expenditures as well as higher administrative costs. This alone, however, would not be enough to explain a cost increase of such magnitude.

3.2 Price per Unit of Output (MWh)

Our MSE analysis shows that MEUs that have deployed IT-based systems for control, monitoring, and automatic meter reading exhibit lower prices for electric power than MEUs that have not made the investments. According to our results, the deployment of IT-based systems by MEUs is associated with \$1.54 lower price per MWh by 2003 (3[A]). Detailed results are shown in **Appendix 3**.

According to the EIA, the average retail price of electricity for 2003 was \$74.2 per MWh (EIA 2006). In comparison, our results suggest that the adoption of IP-enabled SCADA and AMR is associated with prices that are around 2% below the national average for 2003. Our results do not support the concerns that investments in IP-enabled SCADA and AMR would have to be financed by higher electricity prices.

These new IP-enabled solutions allow utilities better monitoring and control of their infrastructure and demand load curves. Benefits include greater efficiency, theft detection, and real-time pricing (Johnston 2003; IBM Business Consulting Services 2004; Black 2005).

Observations from fieldwork suggests that, after deploying IT-based systems, MEUs were able to lower their costs and offer customers better prices. In some cases, they found that average prices per customer prior to installing the new system were higher than the average after using real time pricing of electric power. Why would MEUs lower their prices of electric power?

The main answer might be found in differences between the service orientation of MEUs and investor-owned utilities (IOUs). Rent appropriation created through technological innovations might be a source of revenue for IOUs. The story is different for municipally-owned utilities. In all cases studies, utility managers stated that any

savings from using the new technologies should be shared with their customers in the form of reduced prices for electricity.

IOUs and MEUs have very different strategic goals. IOUs are responsible to their shareholders, but MEUs are also focused on local economic development and social benefits (externalities). They are, for this reason, closer to their local markets' "changing social demands" as defined by Arcelus and Schaefer (1982). Changing social demands beyond the direct demand for a good (e.g. electric power) are strategic issues (Arcelus and Schaefer 1982) for MEUs, but not for IOUs. MEUs have been conceived, built, and operated in order to promote local economic development (Osorio 2004) by providing electric power at the lowest possible price.

3.3 Cross-Subsidies from Electric Power to Communications

Regulators and private telecommunication operators have been worried that MEUs could subsidize their entry into telecommunications by increasing their electricity prices or costs, and transferring portions to their broadband services. If so, they should exhibit higher prices and/or costs per electric power than similar MEUs that do not offer broadband services. There are also questions about the existence of economies of scope between IP-enabled SCADA and AMR. So, Do MEUs subsidize their broadband services with funds from their electric power operations? We take two approaches to answer this question:

- First, we restrict the sample to only those MEUs that became broadband providers and analyzed whether there were any differences associated with the fact that some deployed new generation network technology for internal purposes, and some did not. According to data from APPA, about 10% of the MEUs that deployed broadband services by 2000 had not deployed IP-enabled internal services. See **Table 4**, column B, for results.

In this table, we compare the gains in internal efficiency among MEUs that became broadband providers based on the deployment of new generation internal services with the gains in efficiency of MEUs that became broadband providers, but did not deploy IP-enabled SCADA and AMR. Our analysis shows that MEUs that diversified as a result of functional emergence from their internal networks exhibit considerable gains in efficiency including reduction of electric power prices of \$3.67 per MWh; cost reductions of \$1.44 per MWh for customer service, support and information; and a cost increase of almost \$1 for ACGE (See 1[B]).

Our results suggest that MEUs that offer external broadband but do not use their network to deploy IP-enabled SCADA and AMR are less efficient than those MEUs

that do both. These results are extensions of the Internal Efficiency Hypothesis: among broadband provider MEUs, those that deploy IP-enabled services exhibit higher internal efficiency in everything but ACGE. This could signal the existence of economies of scope in ACGE: (i) these costs increase significantly when MEUs adopt IP-enabled SCADA and AMR (**Table 4**, Column A), (ii) the magnitude and significance of the coefficient decrease when we study the same effect only among MEUs that have become broadband providers (i.e. the basic infrastructure is needed for both purposes) (**Table 4**, Column B), and (iii) the statistical significance of this effect disappears when we study the effect of becoming a broadband provider among MEUs that have adopted IP-enabled services (**Table 4**, Column C).

- The second approach is to examine whether deploying external broadband makes any difference among similar MEUs that have deployed their internal IP-based solutions for system control and monitoring.

We used matched sample estimators to determine whether there was any statistically significant difference in the price or cost of the electric power business between MEUs that deployed external broadband services and those that did not. We considered only MEUs that have adopted IP-enabled SCADA and AMR. As indicated in **Table 4**, column C, the analysis shows no statistically significant difference in either price or cost for electricity between MEUs that have, and have not, deployed external broadband services.

In other words, MEUs that became external broadband providers based on their internal communication networks do not exhibit higher prices or costs than those that did not deploy external broadband. We also find evidence to suggest that increases in administration and general expenses reflect economies of scope between IP-enabled SCADA and AMR and broadband services (e.g. the need for only one general manager, one financial manager, one common bill to consumers, etc.)¹⁵

4 Effect MEU-based Broadband on Local Economic Development

In this study, a MEU is considered to offer external broadband if it provides at least one of the following services: high-speed Internet through cable modem or digital subscriber line (DSL); fiber leasing; broadband transport; wireless services; or the function of an Internet Service Provider. To test the Local Economic Development

¹⁵ Our analysis about economies of scope and cross-subsidies brings interesting results, but they need further examination when more data becomes available in the following years. The results could be affected by sample size, and thus would need further confirmation when better and more data becomes available.

hypothesis, we study the effect of municipal broadband on the growth rate of local business establishments; establishments in IT-intensive sectors; employment; and salary-aggregating data from zip code to place levels. The historical baselines for the dependent variables include the growth rate of business establishments, employment, and salary between 1994 and 1998; the share of business establishments in IT-intensive sectors in 1998; and the growth of labor in the 1990-2000 period. The objective is to test the hypothesis on various fronts and to compare the results to previous research on the local economic impact of broadband at the zip code level in the United States (Lehr, Gillett et al. 2006).

The endogeneity problem between the deployment of technology and its effects requires the consideration of various factors affecting the cost and likelihood of deployment and the likelihood of adoption and use by people and organizations. These factors include cost of deployment, the size of towns and their proximity to large metropolitan areas, and the desire and capacity of the populace to use broadband services.

Cost of deployment, for instance, is strongly affected by household and business density, which affects the fixed cost per subscriber. However, a local network will still need connectivity to the Internet. For this reason, an additional important factor in broadband availability is the cost of connecting a local network to the backbone (backhaul costs). The closer a town is to a large metropolitan area, the lower the backhaul costs will be because it is highly likely there will be an Internet Backbone Provider or a large Internet Service Provider.

The size of towns and proximity to large metropolitan areas is also an important source of economic opportunities in a locality. These arguments have been widely studied by scholars of growth-pole and central place theories, (Parr 1973; North 1975; Polenske 1988). The Urban-Rural Influence Code (UrbInf03) is a variable that has been designed under these assumptions by the Economic Research Service of the U.S. Dept. of Agriculture¹⁶. The rest of the data follows the same rationale as Lehr, Gillett et al (2006).

Finally, broadband becomes productive insofar as it is adopted by people and organizations. People must have certain skills and knowledge to take advantage of this technology (Bresnahan, Brynjolfsson et al. 2002; Autor, Levy et al. 2003). For this reason, we have included the growth rate of college graduates between 1990 and 2000, and the percentage of the local population that held a bachelor degree by 2000 as matching variables.

¹⁶ See <http://www.ers.usda.gov/briefing/Rurality/UrbanInf/>

We analyze the local economic development hypothesis by studying the effect of MEUs' offer of external broadband services on four dependent variables, as shown in **Table 5** and **6**.

These results show that towns where MEUs deployed external broadband services exhibited higher growth rates in local business establishments (See **Table 6**, column A). We do not find a statistically significant relationship between the deployment of broadband by MEUs and the share of IT-intensive business establishments in 2002, the growth rate of employment, or average salaries in the 2000-2002 period. These results are consistent with findings from qualitative research (see Osorio, 2006), but are still not fully conclusive.

Table 5: Summary Statistics: variables for testing Economic Development Hypothesis

Description <i>Description</i>	Name	MEUs in SubSample	MEUs 2000		MEUs 2004	
		N=1314	BB N=47	No BB N=1267	BB N=145	No BB N=1169
Growth Rate of B. Establishments 2000-2002	LnrEst	0.008 (0.092)	0.010 (0.054)	0.008 (0.093)	0.014 (0.067)	0.007 (0.094)
Growth Rate of Employment 2000-2002	LnrEmplo	-0.033 (0.248)	-0.065 (0.174)	-0.032 (0.250)	-0.025 (0.221)	-0.034 (0.251)
Growth Rate of Salary 2000-2002	LnSalary	0.076 (0.146)	0.057 (0.063)	0.077 (0.148)	0.066 (0.077)	0.078 (0.152)
% Establishments in IT- Intensive sectors 2002	ptotIT02	0.223 (0.063)	0.255 (0.058)	0.222 (0.062)	0.242 (0.047)	0.220 (0.064)
Treatment: Municipal Broadband in 2000	MEU_BB2K	0.036 (0.186)

Variables for Matching

=1 if Private Broadband Providers 2000, 0= otherwise	Private	0.874 (0.331)	0.936 (0.247)	0.872 (0.334)	0.937 (0.242)	0.866 (0.340)
Growth Business Establishments 1994-1998	grEst9498	0.067 (0.152)	0.062 (0.141)	0.068 (0.152)	0.058 (0.105)	0.068 (0.156)
Growth Employment 1994- 1998	grEmp9498	0.142 (1.041)	0.078 (0.271)	0.145 (1.059)	0.076 (0.206)	0.151 (1.102)
Growth College Grads 90s	grColl90s	0.371 (0.719)	0.313 (0.256)	0.373 (0.730)	0.393 (0.374)	0.369 (0.751)
Growth Average Salary 1994-1998	grSalary9498	0.174 (0.199)	0.158 (0.161)	0.174 (0.200)	0.158 (0.118)	0.176 (0.207)
% Pop. Bachelor Graduate in 2000	BachGrad2K	16.557 (8.969)	25.206 (12.618)	16.236 (8.646)	20.817 (9.985)	16.028 (8.695)
% Establishments in IT- Intensive sectors 1998	ptotIT98	0.223 (0.058)	0.255 (0.057)	0.222 (0.058)	0.243 (0.044)	0.221 (0.059)
Growth of IT-Intensive establishments 1998-2000	grIT9800	0.012 (0.171)	0.051 (0.297)	0.010 (0.165)	0.025 (0.181)	0.010 (0.170)
Growth Local Employment 1990-2000	grLabor90s	0.095 (0.227)	0.102 (0.154)	0.095 (0.229)	0.109 (0.165)	0.094 (0.233)
Population 2000	Pop2K	15,186 (113,585)	54,001 (101,663)	13,746 (113,785)	51,040 (307,149)	10,739 (51,893)
Urban-Rural Influence	URinfl03	5.336	3.574	5.402	4.248	5.471

Code | | (3.357) (2.756) (3.361) | (3.088) (3.366) |

An additional question is whether these results are affected by the presence of private broadband providers. Some might argue that the introduction of a public broadband provider into a market already served by private providers will not necessarily add economic benefits (Bast 2002; Bast 2005). Others assume that private broadband providers tend to underserve a market because they are not able to appropriate all the benefits from investing in infrastructure (BEA 1999, Ford and Koutsky 2005, Vaishnav forthcoming). Our results support the latter, by finding an additional positive effect associated with the presence of MEU-based broadband, while applying MSE only among towns with private broadband providers. (See Column B in Table 6.)

Table 6: Local Economic Development: Summary Results

Dependent Variable (2000-2002)	Treatment: Deployment of External Broadband Services by 2000	
	(A) Full Sample Estimated Magnitude	(B) Subset – Places with Private Providers of Broadband by 2000 Estimated Magnitude
Growth Rate of Business Establishments	0.01534***	0.01269**
Share of Business Establishments in IT-Intensive Sectors (2002)	-0.0030	-0.0028
Growth Rate of Employment	0.0185	0.02370
Growth Rate of Salaries	0.00168	0.00263
No. of Observations	1,314	1,149

Source: *: Statistically significant at 10% confidence level, **: Statistically significant at 5% confidence level, ***: Statistically significant at 1% confidence level.

We have analyzed the effect of MEU-based broadband in two scenarios: (i) regardless of the presence or absence of private providers, and (ii) in places where there is also a private provider. The small number of places (10) in which MEUs had deployed broadband by 2000 without private competition provides upward biased results, and are not further considered in our analysis. For instance, these results state that MEU-based broadband contributes an additional 21.1% to the growth of local business

establishments. This is clearly an overestimate of the effect of broadband availability on the growth rate of businesses.

4.1 Growth Rate of Local Business Establishments

According to our results, the deployment of broadband by MEUs by 2000 added an additional 1.53% to the growth rate of local business establishments between 2000 and 2002 in their towns (4[A]). To determine this we applied Matched Sample Estimator analysis to the growth rate of local business establishments, as calculated by using the functional form explained in Section 3.2.1. In this case the “treatment” is the deployment of external broadband services by an MEU. We matched towns on the basis of the local population in 2000, growth of business establishments in the period 1994-1998, and the Urban Influence Code. (See **Appendix 4** for detailed results.)

These results are consistent with previous work (Lehr, Gillett et al. 2006) which found that the effect of broadband deployment in the United States on the growth rate of local business establishments between 1998 and 2000 was 1.23%¹⁷. Our results are also consistent with findings from field and qualitative research. This suggested that the main impact on the local economy from the deployment of broadband by MEUs is the adoption of Internet and information technology by local people and businesses. Broadband opportunities have led to telecommuting, the adoption of new practices by local businesses, and the creation of new traditional ventures that, while not profitable based only on local sales, have been successful based on sales generated through the Internet. These results are particularly interesting, considering that there was a recession in the period 2000-2002.

We also wanted to understand the extent to which the deployment of external broadband services by an MEU is good for the local economy in the presence of private broadband providers. More specifically, we wanted to understand the extent to which having a public broadband provider lent additional benefits to a community.

This is based on the hypothesis that a private provider could capture only some of the private and social benefits of broadband, thus motivating them to invest in only part of the an entire broadband infrastructure. The argument is that the social optimum deployment of broadband is larger than the private optimum deployment, due to the presence of externalities.

Our results show that the effects are positive and significant for the period 2000-2002; the growth of local businesses in towns where the MEU deployed high-speed Internet

¹⁷ This work, however, did not make the distinction between the nature of the broadband provider.

services by 2000 in the presence of at least one private broadband provider was 1.26% greater than for similar towns without MEU broadband (4[B]).

4.2 Business Establishments in IT-Intensive Sectors

Our results suggest that no relationship can be established between the deployment of broadband services by MEUs by 2000 and variation in the share of local business establishments in IT-intensive sectors by 2002 (See **Appendix 5** for detailed results). We wanted to test this hypothesis, because the deployment of municipal broadband networks in rural and suburban areas has been supported by the assumption that it will attract knowledge base firms. This result, however, is not surprising for many reasons.

MEU venues tend to be slightly more rural and less dense than the average broadband venue. **Table 5** shows that places where MEUs have deployed broadband are located in counties that, according to the U.S. Department of Agriculture's Economic Research Service, are defined as: (i) "Micropolitan adjacent to large metro" areas (URinfl03=3), (ii) "Noncore adjacent to large metro" areas (URinfl03=4), or (iii) "Micropolitan adjacent to small metro" areas (URinfl03=5)¹⁸. We can define these counties as "sub-urban". Of the 3,141 counties in the United States only 16.43% of them fall into this category; only 7.88% of the nation's population lives in them.

Most zip codes with broadband by the year 2000 in the United States were located in counties in a (i) "Large Metro Area of 1+ million residents" (URinfl03=1), (ii) "Small Metro Area of less than 1 million residents" (URinfl03=2,) or (iii) "Micropolitan adjacent to large metro" areas (URinfl03=3). These cases represent 37.60% of the nation's counties and 84.47% of the United States population.

This is relevant because (i) there is a significantly negative correlation between the percentage of business establishments in IT-intensive sectors and the rural character of a community (See **Table 7**), and (ii) the magnitude of this correlation changed in important ways between 1998 and 2000, and between 2000 and 2002. We cannot say anything about the direction of causality.

Evidence from field research about the diffusion process of broadband among business establishments supports this result. The deployment of broadband stimulated an increase in the number of home-based business and small firms in the retail sector. Instead of attracting new IT-based or high technology firms, broadband enabled local businesses to reach "external" markets, those outside town boundaries, via the Internet.

¹⁸ See <http://www.ers.usda.gov/Briefing/Rurality/UrbanInf/> for more detailed information about the Urban Influence Code.

Ford and Koutsky (2005) also found that municipal broadband stimulates sales in the retail sector. With a few exceptions, MEU broadband did not attract large numbers of new technology-based businesses to towns. This is supported by previous research that states that firms do not make location decisions based on broadband availability (Forman, Goldfarb et al. 2003; Forman, Goldfarb et al. 2005).

Table 7: Rural/Urban Influence Code and IT-Intensive Business Establishments: Pairwise Correlation, and Varying Percentage

Pairwise Correlation	% Business Establishments in IT-Intensive Sectors				
	URinfl03	1998	2000	2002	
	URinfl03	-.1677***	-.2879***	-.1879***	
Percentage of Business Establishments in IT-Intensive Sectors					
URinfl03	% US Counties	% US Population	1998	2000	2002
1	13.15%	53.03%	.2497	.2543	.2589
2	21.52%	29.62%	.2149	.2190	.2223
3	2.93%	1.83%	.1933	.1934	.1965
4	3.92%	0.84%	.2051	.2038	.2042
5	9.58%	5.21%	.1956	.1982	.2011
6	11.40%	2.79%	.1968	.1977	.2011
7	5.89%	0.67%	.1986	.1996	.2020
8	8.98%	3.25%	.1979	.1994	.2020
9	6.40%	1.15%	.2064	.2068	.2089
10	6.30%	0.47%	.2132	.2160	.2120
11	4.39%	0.80%	.2006	.1985	.2057
12	5.54%	0.36%	.2055	.2075	.2080
Average			.2192	.2222	.2255

Source: the author, based on data from USDA's Economic Research Service. ***: Statistically significant at 1%, **: statistically significant at 5%, *: statistically significant at 10% confidence level.

In a recent study focused on the effect of broadband in economic development at the zip code level for the United States, Lehr, Gillett et al. (2006) used MSE to find that broadband availability was associated with a small but statistically significant (0.28%) increase in IT-intensive business establishments. This may be attributable to the fact that most business growth in this sector occurred in or near metropolitan areas where the Rural-Urban Influence Code (URinfl03) equals one, two, or three (See **Table 7**).

4.3 Employment

Our analysis suggests that the deployment of MEU-broadband by the year 2000 cannot be associated with growth in employment between 2000 and 2002. (See detailed results in **Appendix 6, Table A.**) These results are not surprising, and neither support nor contradict theory.

These years were a period of recession in which unemployment in the United States grew from 4% to 5.8%¹⁹. Additionally, as previously discussed, IT-based applications can either complement or substitute for labor (Bresnahan, Brynjolfsson et al. 2002; Autor, Levy et al. 2003). The presence of both effects could easily offset one another. Based on this evidence, the effect of broadband on employment could vary not only across, but also within, industrial sectors. As a result, one sees “ambiguous changes in the direction of total employment growth” (Lehr, Gillett et al. 2006).

In our sample, towns where MEUs deployed broadband show lower employment growth in 1994-1998 than places without municipal broadband, but a higher rate in the period 2000-2002. This is interesting, albeit statistically insignificant at a 10% confidence level.

4.4 Salary

Our results show also no statistically significant effect on the growth rate of salaries in 2000-2002 from the deployment of broadband services by MEUs by 2000 (See **Appendix 7, table [A]**, for detailed statistics). These results are similar to those found for the entire United States and the Appalachian region in previous research (Lehr, Gillett et al. 2006). There are at least two reasons for these findings.

First, one might expect to see productivity gains that might spill over to workers in the form of higher wages. During a recession, however, benefits might come in different forms. Fieldwork research suggests that increases in productivity due to broadband deployment by MEUs by business customers may come in the form of improvements to the quality of life--reducing commuting times or creating possibilities to work from home.

A second reason could be that the samples are not perfect matches. The inclusion of many variables for matching samples increases the difficulty of finding perfect matches with `Nnmatch`. The command’s bias-corrected matching estimator option (*biasadj(.)*) tries to correct the possible bias, but its effectiveness is limited by the data. In this case, it cannot fully correct the bias of not having perfect matches. As seen in **Table 7[A]**, all variables present differences between 5% and 62% among treatment and control groups.

¹⁹ See <http://www.bls.gov/cps/cpsaat1.pdf>

5 Limitations of the Data and our Research

Quality and availability of data impose limitations to our analysis. The most important problems are:

- i. *Broadband deployment versus adoption*: The analysis is based on data about the deployment of IP-enabled SCADA and AMR and external broadband services by MEUs. While deployment signals the availability of the infrastructure, adoption suggests its use, and the economic effect of broadband comes from use. We do not have data on broadband penetration by town. Data about broadband adoption could help us to better estimate the economic effect of MEU-based diversification into broadband services.
- ii. *Timing of market entry*: We do not have data about the timing of market entry for MEUs and private providers. Therefore, our analysis cannot factor in any response to market entry by MEUs or private providers. This information could allow further analysis of our hypotheses by studying how the local economic impact of MEU broadband is associated with different entry scenarios (i.e. impact of having an MEU enter broadband in a market with private providers compared with the impact of having private providers enter a market already served by an MEU).
- iii. *Financial data*: Financial data for MEUs do not perfectly separate costs associated with fuel, operations, and capital investments. The decreases in CSSI and price do not offset the increases in ACGE. We have shown that these costs are associated with deploying IP-based infrastructure and signal the existence of economies of scope between deploying IP-enabled SCADA and AMR and broadband. There is, however, a need for more and better data and further research to fully understand the increase in ACGE.
- iv. *Cross-subsidies*: Our analysis has focused only on one type of cross subsidy: the support of broadband operations with funds from electric power services. We have financial data for all MEUs on their electric power businesses, but none about their telecommunications operations. Therefore, it is not possible to test whether broadband operations might be subsidizing electric power services. How would this happen? We have suggested in Osorio (2006) that the adoption of IP-enabled SCADA and AMR after 2001 created the option for MEUs to diversify into broadband. Following this observation, other MEUs might have planned to deploy these internal services anticipating future revenue streams from their eventual broadband operations. This, however, cannot be tested until more and better data is available.

6 Summary of Results, Conclusions, and Limitations

This chapter has demonstrated that adopting information technology solutions for command and control of electric operations is associated with increased internal efficiency of an electric power business. Additionally, we found no evidence to support the claim that MEUs use resources from their electric power business to subsidize their broadband operations. Finally, our results show that deploying external broadband services is associated with positive effects on local economic development. These results have important implications for policy making.

The deployment of broadband by MEUs presents an interesting case of unexpected diversification and entry into advanced telecommunication services by public actors from another industrial sector. Our research has answered pending questions about this phenomenon. We now discuss some opportunities that could be missed and challenges that need to be addressed.

6.1 *Internal Efficiency Hypothesis: information technology does matter for electric power*

Our analysis shows that the adoption of new generation communications networks for operating IP-enabled SCADA and advanced AMR has a positive effect on the efficiency of municipal electric utilities: (i) electricity prices are nearly \$1.54 per MWh (2%) lower, and (ii) customer service, sales and information costs are about \$0.36 per MWh (30%) lower than in similar MEUs that have not adopted such technology. Our results are discussed as follow:

- i. Our result for energy prices also confirm recent work on the effect of IT on electric power operations (Black 2005). While AMR solutions allow MEUs to better price load demand, SCADA would translate the resultant lower costs into revenue or customer savings. MEUs found that average pricing before installing the broadband-based systems was higher than after deploying them. In such cases, the MEUs' decision reduced their prices and delivered benefits to customers.
- ii. Our results from matched sample regression show that deploying internal IT-based services is associated with lower costs for information, and for customer service and support, but with increases in administrative costs and general expenses, and lower price of electricity (MWh). The effect of internal IT-based services on consumer-related operation costs supports theory about the effect of information technology on transaction and coordination costs in general (Shin

1997; Shapiro and Varian 1998), in the electric power industry (Black 2005), and public organizations (Osorio and Fountain 2001) in particular.

- iii. In the case of Administrative Costs and General Expenses, fieldwork research provided information that illuminated the econometric results. Modern SCADA and AMR and broadband Internet services proved to be competence-enhancing for both linemen and technical staff, but competence-destroying for senior and some technical managers. An important part of the increased expenses for MEUs that deployed internal IT-based services were for hiring experienced managers. This increase was identical for all the MEUs, whether or not they deployed external broadband. The only difference is that, eventually, a broadband provider MEUs could have been able to allocate some of these costs to their broadband division. We have, however, no evidence of this.

We also wanted to know whether deploying IP-enabled internal solutions made any difference among MEUs that have become broadband providers. Studying the existence of gains in efficiency associated with the deployment of internal solutions, while holding constant the deployment of external broadband, allow us to better understand what results from being a broadband provider, and what from deploying internal services. In other words, we tried to measure the existence of economies of scope and possible effect associated with functional emergence.

Again, our results show that, among the MEUs that became broadband providers, those who used the communication networks for controlling and monitoring internal processes of the electric power business were able to offer lower prices and had lower costs than those MEUs that offered broadband services, but not adopted internal solutions. These results confirm that gains in internal efficiency come from the deployment of IP-enabled SCADA and AMR.

6.2 Cross-subsidies: Pricing and Cost of Electric Power

Regulators in both the electric power and telecommunications sectors have worried that the entry of MEUs in telecommunications might impose a burden on energy consumers, and unnecessary risk for MEUs' electric power business. They are also worried that electric utilities might subsidize their telecommunication operations by increasing energy price or the costs associated with their electric power services.

Our analysis of the impacts of new generation internal systems also provided information about the existence of cross-subsidies between electric power and telecommunications.

We tried to find evidence of subsidies from the electric power to communication services among MEUs by applying matched sample estimators to measure the possible effect of becoming a broadband provider on the internal efficiency of the electric power business for those that had deployed IP-enabled systems for control and monitoring. Subsidies would be evident if the MEUs external broadband services demonstrated increased prices or costs for power. Thus, an eventual increase in power price and cost could indicate the transfer of funds from the electric power to telecommunication operations that should be further investigated.

The policy implications of our results are very relevant. On one hand, regulators of the electric power industry have been asking electric utilities to invest in command-and-control technologies that would enhance the reliability of the grid. On the other hand, they worry that such diversification might be financed by increasing rates for electric power.

Our results show that investing in the creation of an intelligent local grid is associated with lower prices and operation costs; also supported by the literature (Johnston 2003; IBM Business Consulting Services 2004; Black 2005), and there is no grounds to support the hypothesis that later diversification into telecommunications is subsidized by results of electric power operations.

6.3 Local Economic Development Hypothesis: broadband deployed by MEUs matter to the economy

Previous work shows that MEU investments in IP-enabled SCADA and AMR are the base for emerged functionality –becoming a local broadband provider (Osorio 2006). Here we show that an MEU becoming a broadband provider has a positive effect on the local economy.

Our research presents a first attempt to measure the economic effects of municipal broadband in general, and from municipal electric utilities in particular, considering data from municipal utilities from the entire continental United States²⁰. Our results show that the deployment of external broadband by 2000 is associated with an extra 1.53% increase to the growth rate of local business establishments between 2000 and 2002. These results confirm previous findings about the economic impact of broadband in the United States, and on the Appalachian region (Lehr, Gillett et al. 2006).

Our analysis goes a step further, and asks whether this apparent effect of municipal broadband on the local economy holds in the presence of private broadband providers.

²⁰ Ford and Koutsky (2005) studied the effect of municipal broadband on retail sales Florida.

In other words, is there creation of value beyond what private provision of broadband can offer? Our analysis show that, even in the presence of private providers of high-speed Internet services, towns where MEUs started offering broadband services by 2000 exhibit a contribution of 1.27% to the growth rate of local business establishments between 2000 and 2002. This additional effect is not seen in similar towns with only private broadband providers. We argue that this additional effect maximizes social the benefits from investment.

As expected, our analysis found no statistically significant relationship between broadband deployed by MEUs and share of either business establishments in IT-intensive sectors, the growth rate of employment, or average salary between 2000 and 2002. When we analyze census data, we can see that the growth of IT-based businesses was highly concentrated in or nearby large metropolitan areas, which represent more than 80% of the United States' population. Typical MEU towns saw a decreasing share of businesses in IT sectors during this period's recession.

Also, our fieldwork research shows that the deployment of MEU broadband has not attracted massive number of IT-based companies. New businesses have come in the form of regular "brick and mortar" businesses or regular businesses attracted from neighboring towns without broadband. In these cases, firms have moved because of the infrastructure and active plans to revitalize commercial districts.

During the recession of 2000, unemployment in the United States grew from 4.0% by 2000 to 5.8% by 2002. It is highly likely that this factor affected the results found here. Additionally, the lack of a statistically significant effect from broadband on employment can be explained by both theory and results from qualitative research.

Theory states that information technology can either complement or substitute for labor (Bresnahan, Brynjolfsson et al. 2002; Autor, Levy et al. 2003). These mixed effects can be perceived across and within industries. Qualitative research does not show evidence of massive immigration of out-of-town workers. It does, however, show that broadband availability has been affecting the local economy and quality of life by means others than increasing salaries: (i) saving commuting times, (ii) allowing local businesses to reach other markets, (iii) creating more productive and less stressful jobs, and (iv) improving quality of life at work.

6.4 Opportunities

MEUs have deployed new-generation fiber optic networks for operating intelligent SCADA and AMR and offering external broadband services. MEUs have increased the efficiency of their electric power operations and created economies of scope for offering

advanced telecommunication services. This phenomenon signals that we might be in the presence of a sustainable model for facilities-based competition in telecommunications.

As local governments face pressure to increase their efficiency, it makes sense to exploit an existing pool of available bandwidth and Internet connectivity. The decreasing cost of fiber optic and network elements makes it more likely that an important number of network industries in general, and electric utilities in particular, will adopt them. As the deployment of networks services running IP-enabled solutions increases, the players offering broadband are more likely to diversify their services. The economies of scope exhibited by the network infrastructure and availability of spare bandwidth could trigger entry from non-traditional actors.

This could further challenge incumbents, and hasten what has been called the death of the core of the telecommunications industry (Vaishnav forthcoming). From the perspective of the qualitative analysis in Osorio (2006), this disruptive effect on telecommunications is consistent with the effects of architectural innovations proposed by Henderson and Clark (1990).

Thus, as technology changes and becomes less expensive, it creates a new type of convergence among network services that has the potential to be far more disruptive than the one we experienced between telephone and cable television. Further investments, which appear inevitable, will give more MEUs the ability to become telecommunications providers. Tomorrow, different types of organizations intensive in the use of bandwidth and information technology could follow.

6.5 Challenges

The potential of this convergence to increase the efficiency of electric utilities and enhance the economic development of suburban and rural America could be limited by public policies designed to regulate technology that is obsolete. There are two policy challenges: (i) state prohibitions to municipal involvement in telecommunications, and (ii) policy making based on unsubstantiated assumptions.

i. State Prohibitions to Municipal Involvement in Telecommunications

The ambiguity of the Telecommunications Act of 1996 (TA96) the policies and position of the Federal Communications Commission about TA96's Section 253(a) led the Supreme Court to rule that the states must decide whether local governments can deploy telecommunication services. As of 2006, 14 states are prohibiting municipal entry in telecommunications.

These policies create several problems. While the United States has lost the leadership in broadband penetration and, despite FCC figures for broadband deployment, suburban and rural areas are still lagging. In this context, broadband availability becomes an increasingly important problem that has a feasible solution, but cannot be implemented.

Furthermore, policies have been very confusing. As previously mentioned, the Governor of Pennsylvania awarded Kutzown's Hometown Utilicom the 2003 Governor's Award for Local Economic Excellence in the category of Information Technology in recognition for their deployment of local broadband services²¹. However, soon after, Pennsylvania passed a law prohibiting any local government or other political subdivision of the state from providing advanced telecommunication services unless no private company either exists or states an "intention" to provide them within 14 months. Verizon, a private broadband provider, was a major proponent of the bill.

John de Figueiredo shows that telecommunication companies have been able to influence the regulatory process directly at the FCC or by judicial means, and have been able to use the "ideological distance" between the FCC and the courts in their favor (Figueiredo 1998; Figueiredo and Tiller 2001). Pennsylvania's precipitous reversal of support for MEU broadband is an example of this phenomenon.

State restriction on the entry of MEUs in telecommunications has two deleterious effects. First, MEUs that deploy internal IP-enabled SCADA and AMR are forced to be inefficient, by being unable to use their spare bandwidth capacity. Second, people living in rural and suburban areas are forcibly underserved, as private providers have little incentives to deploy infrastructure to serve all types of customers. The potential for MEU-based broadband to enhance local economic growth will be lost. State policies restricting MEU entry into broadband will not only limit the potential of MEUs to serve local markets but also dampen economic potential growth within the state.

ii. Policy Making Based on Unsubstantiated Assumptions

Private telecommunications operators have argued that MEUs could subsidize their telecommunication operations by increasing their electric power rates and drive them out of the market by being able to offer lower broadband prices. They have argued that, additionally, this behavior will harm their electric power customers. Based on

²¹ Letter from Dennis Yablonsky, Secretary Desingee, Department of Community and Economic Development, Commonwealth of Pennsylvania, to Frank Caruso, Director of Information Technology, Hometown Utilicom, dated February 14, 2003.

our results, we found no base to support this hypothesis. It has also been assumed that MEUs take unnecessary risks by deploying technology that is too complex for them to understand and handle. Qualitative research uncovered no information in support of this assumption.

Good regulatory policy needs to protect competition rather than specific competitors. In this context, telecommunication policy makers need to consider how technical change affects the regulatory and competitive landscape if they are to foster innovation and competition for economic growth. Telecommunication policy needs to reflect the new technical reality and the potential of broadband deployment by electric utilities in general, and municipal electric utilities in particular.

7 Appendix: Tables from Econometric Analysis

Appendix 1: Effect of IT-Based Internal Systems on Customer Service, Support and Information Costs per MWh, 2003

(A) Effect of IT-Based Internal Services

		MEU_Int2K Coefficient	z-statistic	P> Z	
N=421	CSSle03	-0.3572	-3.85	0.000	
Dep. Variable	Variable	Treatment MEU_Int2K=1		Control MEU_Int2K=0	
		Mean	Std. Dev.	Mean	Std. Dev.
	CSSle03	0.38	0.4737245	0.54	0.89
	CSSle2K	0.38	0.4224147	0.14	4.71
	Pop2K	48108.62	75633.85	86924.97	288892.60
Matching Variables	PurPower2K	86.12%	0.2594776	86.44%	26.12%
	Steam2K	11.58%	0.2380491	10.40%	23.22%
	Hydro2K	0.15%	0.0086923	0.17%	0.94%
	IncPC2K	18639.32	3250.56	18846.20	4591.73
	Rent2K	500.37	108.3781	502.13	141.07

(B) Effect of IT-Based Internal Services, computed in sub-sample that have deployed External Broadband Services

		MEU_IntBB Coefficient	z-statistic	P> Z	
N=44	CSSle03	-1.441055	-6.73	0.000	
Dep. Variable	Variable	Treatment MEU_IntBB=1		Control MEU_IntBB=0	
		Mean	Std. Dev.	Mean	Std. Dev.
	CSSle03	0.6837	0.5719	0.7477	1.1868
	CSSle2K	0.6434	0.6057	-1.0612	10.6605
	Pop2K	77091.64	112496.9	74284.73	65393.47
	PurPower2K	71.15%	33.81%	72.71%	33.35%
Matching Variables	Steam2K	23.60%	32.34%	21.19%	27.96%
	Hydro2K	0.16%	0.81%	0.00%	0.00%
	IncPC2K	19630.93	3872.90	19073.68	6749.77
	Rent2K	553.97	128.31	583.0227	157.11

MEU_IntBB=0 includes only MEUs without internal IP-enabled services and without MEU-based broadband

(C) Efficiency Effect of Deploying Broadband Services, given that MEU deployed IT-Based Internal

		MEU_IntBB Coefficient	z-statistic	P> Z	
N=76		CSSle03	-0.00801	-0.04	0.964
Dep. Variable	Variable	Treatment MEU_IntBB=1		Control MEU_IntBB=0	
		Mean	Std. Dev.	Mean	Std. Dev.
Matching Variables	CSSle03	0.5895	0.5742	0.4797	0.5244
	CSSle2K	0.5527	0.5650	0.4982	0.4673
	Pop2K	78682.93	114340.4	40169.59	24078.71
	PurPower2K	71.92%	34.42%	71.95%	34.96%
	Steam2K	22.91%	32.48%	27.04%	35.07%
	Hydro2K	0.30%	1.12%	0.30%	1.41%
	IncPC2K	18964.91	2981.757	19110.11	2915.452
Rent2K	533.31	119.05	533.54	99.92	

Appendix 2: Effect of IT-Based Internal Systems on Administrative Costs and General Expenses per MWh, 2003

(A) Effect of IT-Based Internal Services

		MEU_Int2K Coefficient	z-statistic	P> Z	
N=421		s_Adm03	19.9357	2.48	0.130
Dep. Variable	Variable	Treatment MEU_Int2K=1		Control MEU_Int2K=0	
		Mean	Std. Dev.	Mean	Std. Dev.
Matching Variables	s_Adm03	15.51	154.509	4.68	5.11
	s_Adm2K	3.93	3.419392	3.96	3.51
	Pop2K	42043.70	57313.35	70538.78	240297.70
	PurPower2K	86.79%	0.2438795	86.95%	24.72%
	Steam2K	10.21%	0.2260957	9.46%	22.03%
	Hydro2K	0.26%	0.0154156	0.25%	1.33%
	IncPC2K	18698.77	4438.113	18911.54	4976.94
	Rent2K	509.00	119.7424	507.32	142.60

(B) Effect of IT-Based Internal Services, computed in sub-sample that have deployed External Broadband Services

		MEU_IntBB Coefficient	z-statistic	P> Z	
N=44		s_Adm03	6.506555	1.34	0.179
Dep. Variable	Variable	Treatment MEU_IntBB=1		Control MEU_IntBB=0	
		Mean	Std. Dev.	Mean	Std. Dev.
Matching Variables	s_Adm03	10.50	119.93	4.73	5.44
	s_Adm2K	3.54	3.45	3.89	3.64
	Pop2K	28478.05	20064.4	61307.27	243686.7
	PurPower2K	88.74%	21.65%	88.90%	22.40%
	Steam2K	8.25%	20.61%	7.36%	19.40%
	Hydro2K	0.14%	0.83%	0.24%	1.29%
	IncPC2K	18501.79	4327.33	18749.7	4491.63
	Rent2K	497.98	114.00	494.55	128.40

MEU_IntBB==0 includes only MEUs without internal IP-enabled services and without MEU-based broadband

(C) Efficiency Effect of Deploying Broadband Services, given that MEU deployed IT-Based Internal Services

		MEU_IntBB Coefficient	z-statistic	P> Z	
N=76	s_Adm03	6.506555	1.34	0.179	
Dep. Variable		Treatment MEU_IntBB=1		Control MEU_IntBB=0	
Variable		Mean	Std. Dev.	Mean	Std. Dev.
	s_Adm03	5.049	3.631	34.22	248.20
	s_Adm2K	4.692	3.379	4.751	3.732
	Pop2K	75452.36	97016.78	35264.46	22227.83
	PurPower2K	76.24%	31.74%	76.53%	32.49%
	Steam2K	19.62%	30.29%	20.13%	32.89%
	Hydro2K	0.58%	2.07%	0.36%	1.24%
	IncPC2K	19122.92	3142.405	19591.46	5343.159
	Rent2K	535.00	113.90	534.55	122.17

Appendix 3: Effect of IT-Based Internal Systems on Price per MWh, 2003

(A) Effect of IT-Based Internal Services

		MEU_Int2K Coefficient	z-statistic	P> Z	
N=421	PMwh03	-1.542	-1.73	0.084	
Dep. Variable	Variable	Treatment MEU_Int2K=1		Control MEU_Int2K=0	
		Mean	Std. Dev.	Mean	Std. Dev.
	PMwh03	65.41	13.93386	66.12	17.17
	PMwh2K	63.50	14.9204	63.57	16.50
	Pop2K	40,144	56,546	62,349	221,913
Matching Variables	PurPower2K	87.67%	0.2382543	87.35%	24.38%
	Steam2K	9.71%	0.2217006	9.20%	21.74%
	Hydro2K	0.25%	0.0151956	0.23%	1.30%
	IncPC2K	18679.77	4139.556	18863.01	4703.07
	Rent2K	503.44	112.662	507.78	134.61

(B) Effect of IT-Based Internal Services, computed in sub-sample that have deployed External Broadband Services

		MEU_IntBB Coefficient	z-statistic	P> Z	
N=44	RMwh03	-3.67486	-2.23	0.026	
Dep. Variable	Variable	Treatment MEU_IntBB=1		Control MEU_IntBB=0	
		Mean	Std. Dev.	Mean	Std. Dev.
	RMwh03	65.57	15.58	67.20	19.26
	RMwh2K	63.61	15.78	64.59	18.02
	Pop2K	52936.11	84153.96	108476.8	384373.7
Matching Variables	PurPower2K	79.06%	30.31%	79.69%	30.48%
	Steam2K	16.68%	28.93%	17.41%	28.60%
	Hydro2K	0.26%	01.66%	0.06%	0.25%
	IncPC2K	19176.62	3254.68	19384.27	5202.53
	Rent2K	539.37	127.00	549.37	164.88

MEU_IntBB==0 includes only MEUs without internal IP-enabled services and without MEU-based broadband

(C) Efficiency Effect of Deploying Broadband Services, given that MEU deployed IT-Based Internal

		MEU_IntBB Coefficient	z-statistic	P> Z	
N=76	RMwh03	0.94245	0.27	0.790	
Variable		Treatment MEU_IntBB=1		Control MEU_IntBB=0	
Dep. Variable		Mean	Std. Dev.	Mean	Std. Dev.
	RMwh03	65.55	14.57209	66.73	15.76846
	RMwh2K	63.68	16.2076	66.15	15.44682
	Pop2K	76771.24	95635.88	32974.28	21697.07
	PurPower2K	76.66%	31.90%	78.70%	33.34%
Matching Variables	Steam2K	18.76%	29.84%	19.00%	33.22%
	Hydro2K	0.51%	2.01%	0.29%	1.18%
	IncPC2K	18950.26	3030.881	19215.55	5371.655
	Rent2K	530.72	105.3828	531.90	125.7959

Appendix 4: Effect of Municipal Broadband on Growth of Business Establishments

(A) Growth Rate of Business Establishments 2000-2002, Unrestricted

		Coefficient	z-statistic	P> Z	
N=1,314	InrEst	0.01534	2.79	0.005	
Variable		Treatment BB2K =1		Control BB2K =0	
		Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	InrEst	0.0207	0.0417	0.0070	0.0933
Matching Variables	Pop2K	19391	112474	12939	56976
	grEst9498	0.0593	0.1018	0.0680	0.1509
	URinfl03	5.2291	3.2649	5.3409	3.3543

(B) Growth Rate of Business Establishments 2000-2002, Restricted by Presence of Private Providers

		Coefficient	z-statistic	P> Z	
N=1,149	InrEst	.0126931	2.31	0.021	
Variable		Treatment BB2K=1		Control BB2K =0	
		Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	InrEst	0.0195	0.0416	0.0085	0.0845
Matching Variables	Pop2K	17883	111341	13285	57170
	grEst9498	0.0616	0.0990	0.0704	0.1489
	URinfl03	5.0661	3.231	5.1749	3.3367

Appendix 5: Effect of Municipal Broadband on Percentage of Business Establishments in IT-Intensive Sectors

(A) Percentage of Business Establishments in IT-Intensive Sectors 2000-2002, unrestricted

		Coefficient	z-statistic	P> Z	
N=1,314	ptotIT02	-0.00308	-0.88	0.380	
Dep. Variable	Variable	Treatment BB2K =1 Mean	Std. Dev.	Control BB2K =0 Mean	Std. Dev.
	ptotIT02	0.2254	0.0479	0.2225	0.0622
Matching Variables	Pop2K	19894	111412.6	12499.57	55790.24
	pIT98	0.2305	0.0435	0.2233	0.0577
	grColl90s	0.3390	0.3068	0.3700	0.7186
	pcollege2K	17.3071	7.6131	16.5374	8.9505
	grpIT9800	0.0016	0.1066	0.0108	0.1646
	URinfl03	5.0556	3.1109	5.3356	3.3591

(B) Percentage of Business Establishments in IT-Intensive Sectors 2000-2002, Restricted to Presence of Private Providers

		Coefficient	z-statistic	P> Z	
N=1,149	ptotIT02	-0.00364	-1.2	0.229	
Dep. Variable	Variable	Treatment BB2K =1 Mean	Std. Dev.	Control BB2K =0 Mean	Std. Dev.
	ptotIT02	0.2257	0.0473	0.2225	0.0599
Matching Variables	Pop2K	19462.07	111506.7	12880.56	56622.73
	pIT98	0.2306	0.0428	0.2234	0.0550
	grColl90s	0.3479	0.3108	0.3820	0.7105
	pcollege2K	17.46	7.69	16.87	9.04
	grpIT9800	0.0016	0.1071	0.0110	0.1635
	URinfl03	4.87	3.08	5.16	3.34

Appendix 6: Effect of Municipal Broadband on Growth of Employment

(A) Growth Rate of Employment 2000-2002, unrestricted

		Coefficient	z-statistic	P> Z	
N=1,314	InrEmplo	0.0185	1.07	0.285	
Dep. Variable	Variable	Treatment BB2K =1		Control BB2K =0	
		Mean	Std. Dev.	Mean	Std. Dev.
	InrEmplo	-0.0199	0.1495	-0.0292	0.2463
Matching Variables	Pop2K	17127	112445	13070	57018
	gEmp9498	0.0869	0.1703	0.1424	1.0411
	URinfl03	5.2725	3.2736	5.3364	3.3573

(B) Growth Rate of Employment 1998-2002, Restricted to Presence of Private Providers

		Coefficient	z-statistic	P> Z	
N=1,149	InrEmplo9802	-0.00159	-0.06	0.956	
Dep. Variable	Variable	Treatment BB2K =1		Control BB2K =0	
		Mean	Std. Dev.	Mean	Std. Dev.
	InrEmplo9802	-0.0153	0.1461	-0.0305	0.2310
Matching Variables	Pop2K	15605.19	111240.8	13440	57234.43
	gEmp9498	0.0899	0.1655	0.1481	1.1084
	URinfl03	5.1114	3.2534	5.1697	3.3399

Appendix 7: Effect of Municipal Broadband on Growth of Salary

(A) Growth Rate of Salary 2000-2002, unrestricted

		Coefficient	z-statistic	P> Z	
N=1,314	LnrSalary	0.00168	0.09	0.929	
Dep. Variable	Variable	Treatment BB99=1		Control BB99=0	
		Mean	Std. Dev.	Mean	Std. Dev.
	LnrSalary	0.0756	0.1044	0.0769	0.1467
Matching Variables	Pop2K	20414	111123	12525	55882
	grColl90s	0.3220	0.3078	0.3699	0.7188
	grSalary9498	0.1577	0.0955	0.1735	0.1977
	pcollege2K	17.6253	8.3406	16.5283	8.9956
	grLabor90s	0.0831	0.1461	0.0957	0.2266
	URinfl03	5.0852	3.2035	5.3402	3.3582

(B) Growth Rate of Salary 1998-2002, Restricted to Presence of Private Providers

		Coefficient	z-statistic	P> Z	
N=1,149	LnrSalary9802	-0.0176	-1.18	0.240	
Dep. Variable	Variable	Treatment BB99=1		Control BB99=0	
		Mean	Std. Dev.	Mean	Std. Dev.
	LnrSalary9802	0.0779	0.1025	0.0768	0.1368
Matching Variables	Pop2K	19728.69	111331.8	12939.82	56735.56
	grColl90s	0.3264	0.3152	0.3813	0.7104
	grSalary9498	0.1550	0.0971	0.1679	0.1924
	pcollege2K	17.8362	8.5136	16.8678	9.1013
	grLabor90s	0.0854	0.1443	0.0970	0.2265
	URinfl03	4.9321	3.1985	5.1749	3.3419

8 References

- Abadie, A., D. Drukker, et al. (2001). "Implementing matching estimators for average treatment effects in Stata." Stata Journal 4(3): 290-311.
- Arcelus, F. and N. Schaefer (1982). "Social Demands as Strategic Issues: Some Conceptual Problems." Strategic Management Journal 3(4): 347-357.
- Autor, D., F. Levy, et al. (2003). "The Skill Content of the Technology Change." Quarterly Journal of Economics 118(4): 1279-1333.
- Bast, J. (2002). Municipally Owned Broadband Networks: A Critical Evaluation. Chicago, IL, The Heartland Institute: 24.
- Bast, J. (2005). Municipally Owned Telecom Networks, an Economic Boondoggle. Annual Meeting of the Telecommunications Association of Michigan. Dearborn, MI.
- Black, J. (2005). Integrating Demand into the U.S. Electric Power System: Technical, Economic, and Regulatory Frameworks for Responsive Load. Engineering Systems Division. Cambridge, MA, Massachusetts Institute of Technology. **PhD:** 432.
- Bresnahan, T., E. Brynjolfsson, et al. (2002). "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm Level Evidence." Quarterly Journal of Economics 117(1): 339(38).
- Campbell, D. and J. Stanley (1963). Experimental and Quasi-Experimental Designs for Research. Chicago, RandMcNally.
- EIA (2006). Energy Prices, Table 9.9: Average Retail Prices of Electricity. Excel. Washington, DC, US Department of Energy.
- Figueiredo, J. M. (1998). Litigating Regulation: Corporate Strategy in Telecommunications. Academy of Management Proceedings 2000.
- Figueiredo, J. M. and E. H. Tiller (2001). "The Structure and Conduct of Corporate Lobbying: How Firms Lobby the Federal Communications Commission." Journal of Economics & Management Strategy 10(1): 91-122.
- Flamm, K. (2004). The Role of Economics, Demographics, and State Policy in Broadband Competition: An Exploratory Study. 32nd Telecommunications Policy and Research Conference. Arlington, VA.
- Forman, C., A. Goldfarb, et al. (2003). How Did Location Affect Adoption of the Commercial Internet? Global Village, Urban Density, and Industry Composition, National Bureau of Economic Research: 46.
- Forman, C., A. Goldfarb, et al. (2005). "Geographic Location and the Diffusion of Internet Technology." Electronic Commerce Research and Applications 4: 1-113.

- Gabel, D. and F. Kwan (2000). Accessibility of Broadband Communication Services by Various Segments of the American Population. 28th Telecommunications Policy Research Conference, Alexandria, VA.
- Gillett, S. E., W. Lehr, et al. (2006). "Municipal Electric Utilities' Role in Telecommunications Services." Journal of Telecommunications Policy **forthcoming**.
- Grubestic, T. (2004). "The Geodemographics Correlates of Broadband Access and Availability in the United States." Telematics and Information **21**: 335-358.
- Haltiwanger, J. and R. Jarmin (2000). Measuring the Digital Economy. Understanding the Digital Economy: data, tolls, and research. E. Brynjolfsson and B. Kahin. Cambridge, MA, The MIT Press: 13-48.
- Holtz-Eaking, D. and A. Schwartz. (1994). "Infrastructure in a Structural Model of Economic Growth." NBER Working Paper No. 4842 Retrieved March 16, 2006, from <http://www.nber.org/papers/w4824.v5.pdf>.
- IBM Business Consulting Services (2004). The Power of Working Smarter: building the intelligent electricity network, IBM Institute for Business: 18.
- Johnston, G. (2003, April 24th, 2004). "Taking a crack at revenue robbers: Utilities use AMR to detect theft." Electric Light & Power Retrieved June, 2004, from <http://www.chartwellinc.com/pressELP-June2003.pdf>.
- Kennedy, P. (1998). A Guide to Econometrics. Cambridge, MA, MIT Press.
- Lehr, W., S. E. Gillett, et al. (2006). Measuring Broadband's Economic Impact. Prepared for the U.S. Department of Commerce, Economic Development Administration. Cambridge, MA, Massachusetts Institute of Technology's Communications Futures Program: 51.
- North, D. (1975). Location Theory and Regional Economic Growth. Regional Policy. J. Friedmann and W. Alonso. Cambridge, MA, MIT Press: 332-347.
- Osorio, C. (2004). "Bits of Power: The Involvement of Municipal Electric Utilities in Broadband Services." MSc Thesis, Massachusetts Institute of Technology Retrieved October 10, 2005, from http://itc.mit.edu/itel/students/papers/osorio_thesis.pdf.
- Osorio, C. (2006). Functional Emergence and Architectural Innovations in Engineering Systems. Engineering Systems Division. Cambridge, MA, Massachusetts Institute of Technology. **Ph.D.**
- Osorio, C. and J. Fountain (2001). Public Sector: Early Stage of a Deep Transformation. The Economic Payoff From the Internet Revolution. R. Litan and A. Rivlin. Washington, DC, Brookings Institution: 235-268.
- Parr, J. (1973). "Growth Poles, Regional Development, and Central Place Theory." Papers of the Regional Science Association **31**: 173-212.

- Polenske, K. (1988). Growth-Pole Theory and Strategy Reconsidered: Domination, Linkages, and Distribution. Regional Economic Development: Essays in Honour of François Perroux. B. Higgins and D. J. Savoie. Boston, Unwin-Hyman: 91-111.
- Prieger, P. (2003). "The Supply Side of the Digital Divide: Is There Equal Availability in the Broadband Internet Access Market?" Economic Inquiry 41(2): 346-363.
- Shadish, W., T. Cook, et al. (2002). Experimental and Quasi-Experimental Design for Generalized Causal Inference. Boston, MA, Houghton Mifflin Company.
- Shapiro, C. and H. Varian (1998). Information Rules: A Strategic Guide to the Network Economy. Cambridge, MA, Harvard Business School Press.
- Shin, N. (1997). The impact of information technology on coordination costs: implications for firm productivity. International Conference on Information Systems, Atlanta, GA, Association for Computing Machinery.
- Vaishnav, C. (forthcoming). The End of Core: Is incremental policy response optimal for regulating disruptive innovation in telecom? Engineering Systems Division. Cambridge, MA, Massachusetts Institute of Technology. **PhD**.
- Wooldridge, J. (2003). Introductory Econometrics: A Modern Approach, Thompson: South-Western.