Economic Impact of Ubiquitous Wireless Internet in South Carolina

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Executive Summary

Based upon interviews and research of wireless Internet networks being constructed or proposed around the nation, we estimated the costs involved in constructing such a network and the expected revenues and cost savings associated with it. We assumed that the network would consist of WiMAX technology in rural areas and Wi-Fi mesh technology in urban areas. Using acomputer-based general equilibrium model, we examined the impact on the state's economy of two basic scenarios: a network that is entirely constructed and owned by the government and a public-private venture where the government provides use of its towers and the network is privately-developed.

Our findings indicate that both models generate positive economic benefits in terms of jobs, gross state product and per capita disposable income. Of the models, the public-private network shows the greatest positive impact. In this model, the leveraging of government resources would reduce the cost of developing the network, thereby increasing the ability for private developers to build out the network in rural areas.

Urban Wi-Fi networks are already proving to be profitable business ventures. The purely publicly-funded model, therefore, while showing positive impacts on the economy in the long run, would threaten to "crowd out" private developers that are already investing in constructing urban Wi-Fi networks in many of the state's urban areas. We do not believe this would be beneficial use of public money versus the more clearly beneficial public-private model.

I. Introduction

In this section of our report, we present our estimation of the impact of ubiquitous wireless Internet access to South Carolina's economy. This impact is presented in terms of the change in state output and the impact on per capita disposable income. In order to place these estimates in their proper context, the sections preceding oureconomic simulations discuss the ways in which wireless Internet can benefit business and government as well as serve as an amenity for attracting skilled labor and tourists. We also discuss a number ofconsiderations that must be made regarding a statewide wireless network, including the business and usage models chosen and the question of who would own the network. We begin, however, with a brief introduction to wireless Internet technology and the strengths and weaknesses of each of the various options.

II. Primer onWireless Technology

The most common technology used for wireless Internet is Wireless Fidelity, also known as Wi-Fi. This is a low-power radio technology operating on the 2.4 GHz wavelength, which is a radio frequency that is not licensed by the FCC. Advantages to this technology are that the radios are inexpensive and the technology is pervasive – that is, all laptops produced within the past several years are equipped with Wi-Fi technology, allowing users to easily access any publicly-available network without any customization of their computer necessary. The disadvantage to Wi-Fi is that it is a local area network technology, meaning that it has a very limited range (typically only about a hundred yards) and each radio unit is only able to support about 20 users. Another drawback to Wi-Fi is that it is a technology that is likely to be outmoded in the next few years.

The most typical configuration used for municipal Wi-Fi networks is "mesh". This is the interconnection of radios within an area to allow users to move about freely from one transmitter to another, and even helps to extend the distance covered by the network by allowing Wi-Fi radios in a user's laptop to relay asignal from another user's computer back to the network. This configuration allows for less "deadzones" within a covered area, and provides greater mobility. Wi-Fi radios can be mounted in many cases on existing infrastructure, including buildings, utility poles, water towers and so forth.

The type ofwireless technology that appears to be poised to eventually replace Wi-Fi is WiMAX. WiMAX, uses radio frequencies that are typically in the 2.5 GHz wavelength range. This is a frequency that is currently licensed by the FCC, but some of our sources indicate that this may change in the future[1]. Currently, a few locations within the United States are using "Pre-WiMAX" technology, which involves WiMAX transmitters operating on the 2.4 GHz wavelength (the same frequency as Wi-Fi). Like Wi-Fi, WiMAX and Pre-WiMAX "base units" can also be mounted on existing infrastructure. Since they cover a broader area than Wi-Fi, they are typically mounted on bases with a higher elevation, such as tall buildings or water, radio and cell towers. Several of our sources have indicated that there is already sufficient infrastructure in South Carolina on which to mount transmitters for such a network.[2]

The advantages of WiMAX over Wi-Fi are that WiMAX is a metro-area network technology, that is, it has a much greater range than Wi-Fi – up to about seven miles – and is able to support two to three times as many users per radio unit.[3] As a result, while WiMAX radios are currently much more expensive than Wi-Fi units, significantly fewer units will be required to cover a given area. WiMAX also is more conducive to technologies such as Voice over IP (VoIP, which is telephone service provided over the Internet, currently offered for example by Vonage) than is Wi-Fi. Some disadvantages to WiMAX are that the technology is emergent, so no WiMAX-ready laptops are currently in production in the US. Intel is expected to begin production of WiMAX chipsets for laptop computers circa 2008, but this date is as yet uncertain. An additional cost associated with WiMAX is that indoor users (those using WiMAX at home or in the office) may require the installation of a consumer interface box, so-called Consumer Premise Equipment (CPE) – this could be done either on ahousehold-by-household basis, or, in an area where a number of users are in a relatively close proximity, the box could be installed in one central location for several users.[4]

Since Pre-WiMAX technology allows the same advantages over Wi-Fi that "true" WiMAX does, it can be used in the interim before WiMAX becomes widely available, but some *caveats* do apply. First, while the cost of Pre-WiMAX equipment is currently lower than that of true WiMAX, the technology is not entirely interchangeable; in other words, should a transition to true WiMAX ever occur, the radio units would have to be physically upgraded to be able to operate in the 2.5GHz range, which would entail significant cost. Also, end users would still require the box to be installed as described above in order to access the Pre-WiMAX network. Finally, using Pre-WiMAX as a long-term solution (that is, not upgrading to true WiMAX) could present interoperability problems in that some of oursources have indicated that PDAs and other hand-held

[1] There are advantages to the frequencies being licensed. Unlicensed frequencies can become very crowded, increasing the probability of interference or difficulty of access due to overuse. A licensed frequency, such as that currently used for WiMAX, protects against these problems.

[2] In the cases where these towers are not owned by the state or municipality, agreements will have to be reached with the owners for mounting the transmitters. This may involve a rental agreement or, as many privately-owned networks have done in order to gain access to government structures, some in-kind agreement.

[3] WiMAX typically covers between forty to sixty users per radio unit. However, the transmitters can be configured as either single in single out (SISO) or multiple in multiple out (MIMO). SISO means that any given user only has access to a single node. MIMO means that the transmission ranges of multiple towers overlap, allowing some users to potentially access more than one tower. This would effectively increase the number of users that can be served per radio unit.

[4] In some cases, CPEs must also be used with Wi-Fi.

technologies will in the future be configured for use with WiMAX technology; therefore a Pre-WiMAX system would apparently not work with this technology when that occurs.

Some municipalities we have interviewed are configuring their wireless networks to use Wi-Fi mesh technology for user interface, which would allow users to access the network easily with current laptop technology, and WiMAX (or Pre-WiMAX) to connect the various nodes of the network and for "backhaul" (this will be discussed in following paragraphs). This could provide an acceptable alternative to an entirely WiMAX network, but there remains the probability that the Wi-Fi components would eventually need to be phased out and replaced with WiMAX or some as yet unforeseen next-generation technology.

In looking at a statewide network, some flexibility can exist in the technology, as some of the state's urban centers are already constructing Wi-Fi networks. The technology that is projected to be released in laptop computers circa 2008 will be dual mode – that is, it will function with either Wi-Fi or WiMAX. Therefore, WiMAX could, for example, be used in more sparsely-populated areas, due to its superior range, while Wi-Fi could continue to be used in more densely-populated areas.

"Backhaul" refers to the connection of the wireless network back into the "wired" Internet. This can be accomplished basically in two ways. First, the backhaul can be hardwired – the network can connect directly into a physical optical fiber line that would either preexist at the location or would need to be run to the location. Some municipal systems with whom we have spoken already owned their own fiber, which greatly diminished the cost to them of backhaul relative to places that did not own preexisting fiber.

The second option for backhaul is that discussed previously of using WiMAX for a wireless backhaul. This would involve using WiMAX radios to connect tower-to-tower back to a point where a physical fiber connection already exists.[5] Theadvantages of this method are that it avoids some of the costs of laying new fiber, should fiber not already exist locally, and may allow for easier maintenance insofar as radio transmitters are above-ground and fiber is often buried and therefore more difficult to access. Particularly in the case ofmore remote areas where the nearest fiber access point is very distant, wireless backhaul may be the more cost-effective solution.

III. Potential Benefits of Ubiquitous Wireless Internet

Ubiquitous wireless Internet access is predicted to primarily generate benefits in two areas. These benefits can be expected to present in savings to business and government due to increased efficiency and productivity and in amenity values.

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[5] For tower-to-tower transmission, WiMAX utilizes a 5.8 GHz frequency which is currently unregulated by the FCC.

A. Productivity and Efficiency Gains

Based upon our findings from the literature and the interviews we have conducted, the advantages of the wireless environment occur primarily as gains in productivity and efficiency. A major trend in the business sector is a move toward teleworking, which includes telecommuting, telemedicine, distance learning, and teletrade or e-commerce. Teleworking involves the use of telecommunications to change the geography of where we work. It is used to avoid the costs associated with the use of transportation for travel to and from the traditional workplace. Telework additionally includes working from anywhere as the opportunity to do so presents itself – automobile, airport lounge, telework center or branch or satellite office, a client's office, a café orhotel room. This new ubiquity of the workplace is sometime called "flexiplace" working. Telework is a business management strategy and not a means of relieving the employee of the personal burden of having to commute. The main benefits include:

- Improved quality of work-life; stress reduction;
- Improved competitiveness, in terms of individual and organizational productivity and enhanced governmental services level efficiency;
- Improved capability to recruit and retain workers;
- Real Estate cost savings, in terms of a lessened requirement for office space;
- Introduction of "stealth" process re-engineering –improved management methodologies and practices;
- Absenteeism can be reduced;
- Reduction in unproductive time spent commuting to the office;
- Brings employment to underemployed segments of the population such as retirees, disabled, workers in inner urban areas, geographical remote areas, military spouses, areas with decline in manufacturing, farming or military installations have been closed;
- Reduction in mobile toxic gas emissions, pollution runoff into waterways & preservation of limited natural resources (oil) and green spaces.

Many of these benefits could prove empowering to small businesses and to entrepreneurs. They could also improve the speed and efficiency of decision-making, even in large firms.

Some industries may not consider their specific business environment to be conducive to teleworking due to the following factors:

- Difficulty of monitoring output of remote workers
- Loss of perceived benefits of face to fact contact
- Company operates in intensively client-facing environment
- Incomplete access to network applications and content
- Opposition from senior management
- Security concerns centered on remote working
- Cost of ensuring remote workers have decent access to network

- Perceived threat to company culture.[6]

As a case in point, PDI, a US supplier of outsourced sales and marketing services to the bio-pharmaceutical and medical device industries, now has 90% of its workforce working remotely. Most employees receive instructions (including on regulatory compliance issues) and send reports from their home PCs via the corporate network. The company is currently phasing in handheld PCs. PDI is building anetwork supporting video and real-time information sharing that will allow its remote workers to come into a virtual office simply by logging on. The company's rapid staff employee growth rate from 100 in 1994 to more than 300 would have been impossible without remote working technology. Sun Microsystems has converted 17,000 employees to its iWork scheme for remote working. More than half its workforce now has no assigned office. Instead, they can reserve shared work places or work from home. Through iWork, Sun is cutting 30% of its office space. Employee satisfaction with iWork runs at 73%. With reduction in office space and improvements in productivity, Sun calculates overall saving in 2004 of more than $100 million through iWork and hopes to increase to $140 million annually when fully implemented.[7]

An Ovum study[8] states that the United States has outpaced Japan and the European Union in labor productivity growth over the last ten years. A primary reason for this is the adoption of information technology (IT), computers and telecommunications to reengineer business practices and improve productivity. Wireless data services improved US productivity gains in 2004 in excess of $8 billion. According to Ovum, wireless data services are almost as large as the total GDP of Bahrain, based on World Bank estimates.

Productivity and efficiency improvements benefit governments as well as private firms. To date, almost 500,000 cities, states, and countries globally are in the early stages of development of systems to provide "one stop" instant access to government services, although such electronic access to government is available without requiring wireless networks. With ubiquitous wireless access, however, additional benefits can be accrued, such as more government workers working in communities instead of behind desks, and reduction in service-delivery costs, particularly in overtime cost reductions dueto an ability for workers to file reports and access information from the field rather than having to return to the office. One additional advantage of this portability is that, insofar as it allows public safety officers to spend more time on patrol rather than at headquarters, and that it provides more rapid access to information, emergency services – including police and rescue – personnel gain the ability to respond more rapidly to emergencies.

As an example ofsome of the quantifiable benefits of wireless connectivity, the Georgia Board of Pardons and Paroles studied the supervision of inmates released prior to the completion of their prison sentence.[9] Theagency has a highly mobile workforce of more

[6] http://www.telcoa.org
[7] AT&T Point of view/Remote Networking, November 24, 2004.
[8] "The impact of the US Wireless Telecom Industry on the US Economy", September 2005.
[9] "Wireless Survey Analysis", The Georgia Board of Pardons and Paroles (2002).

than 320 field officers who need access to the agency's centralized applications to supervise the paroled inmates. An overwhelming majority of the field agents agree or strongly agree that wireless helps them be more productive. They reported improved communication, improved access to information and improved job flexibility as measures of productivity improvement. On the average agents were able to increase their field supervision by more than eight hours. 96 percent of the respondents surveyed responded that the way they perform their jobs duties improved as a result of wireless. All agency application usage was virtually identical for each of the applications. Employees used wireless services during non-traditional work hours. For example, employees used wireless on vacation, at home or during times when they would not normally be working. Employees cited work flexibility as a major benefit of wireless. Wireless was used in a wide variety of locations; from homes, office, or roadside in vehicles.

B. Amenity Value

Amenity value is important because of its significance in attracting highly mobile skilled and professional workers, which in turn attracts high tech employers.[10] Sometimes called "quality of life", amenity value refers to a set of benefits offered by an area to its residents, including culture, good schools, recreation, a low crime rate, and other less tangible attributes such as climate and natural scenery. A seminal study by Richard Florida demonstrated the benefit that such amenity value garners an area through the attraction of skilled technical workers. Florida emphasized the importance of cultural amenities for drawing what he termed the "creative class", i.e., high-tech professionals and entrepreneurs. Florida listed such attributes as "experiential" amenities – such as art galleries, theaters and musical venues – and elements of local character such as historical landmarks and a vibrant downtown and established neighborhoods.[11] To some degree, the preceding discussion of teleworking contributes to the amenity value of wireless Internet, as skilled technical workers are likely to be drawn to an area that offers low-cost and ubiquitous access to the resources necessary to "stay connected". Amenity value also contributes to the attractiveness of a location to tourists and consumers. Both of these are expected to be enhanced by the presence of ubiquitous wireless Internet access.

Florida, in a 2006 article, pointed out that as of 2000, the distribution of college graduates in the nation had become more concentrated around a relatively small number of urban areas, what he termed "superstar cities", relative to thirty years earlier. [12] In 1970, college graduates were fairly evenly distributed across the nation. By the 2000 Census, the percentage of college graduates had increased significantly, but the distribution had become much more clustered with substantial portions of the nation well below the national average of graduates per 100 residents. South Carolina was certainly not an exception. In 1970, a majority of the state's counties had a percentage of college

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[10] Edward J. Malecki, "Industrial Location and Corporate Organization in High Technology Industries" (Economic Geography 61, 1985) pp.345-369.
[11] Richard Florida, "The Rise of the Creative Class" (The Washington Monthly, May 2002). Internet: http://www.washingtonmonthly.com/features/2001/0205.florida.html
[12] Richard Florida, "Where the Brains Are" (The Atlantic Monthly, October 2006) pp.34-36.

graduates that fell within 4 points of the national average, and one county (Richland) was well above the average; in 2000, the number of counties within four points of the national average dropped to eight, although the number of counties that ranked well above average increased to three (Beaufort, Charleston and Richland).

Florida attributed this largely to the economic efficacy of "educated elites" living in close proximity to one another in order to maximize their income potential – in other words, the jobs and the innovation are where the brains are. According to Florida, "What matters today isn't where most people settle, but where the *greatest number of the most-skilled* people does" (emphasis in original text). Therefore, amenities that draw this "creative class" of workers are highly beneficial to any state.

IV. Usage Models

It is important that the usage model, i.e. the type of usage expected to be covered by the wireless network, be carefully considered. Usage here refers to whether the network is intended to provide service for users that are stationary, nomadic or truly mobile. It also considers whether the network is intended to be accessible only from outdoor locations or from indoors as well.

Stationary means that users will only use the network in a single location. This essentially provides no benefit above that of current "wired" networks like DSL orT1 lines and is not a likely model for ubiquitous wireless Internet. Nomadic means that users may access the Internet from any location within the network, but they will need to be relatively stationary while connected to the Internet; in other words, they would not be able to maintain a constant connection while driving down the Interstate, for example. They would be mobile, however, insofar as they would be able to move about within the range ofa specific radio unit. This is the most common configuration for wireless networks, and it is the technology we have assumed in our cost assumptions. The final usage model is truly mobile access, which would allow users to be "handed off" from one radio unit to another as they move between "cells" (in much the same way as is currently done by cellular telephone networks). Constructing a network that offers this kind of mobility, however, would have to be added on top of the nomadic configuration and would therefore entail more cost than that presented in this study. However, true mobility could be added to the network, or to portions of the network, at any point in time.

Networks that only provide outdoor access require less capital cost, since they do not require CPEs to propagate the wireless signal within manmade structures. A network with only outdoor access is not extremely practical, however, as much, if not most, network usage can be expected to take place indoors. The simulations in this study assume a network configured for both outdoor and indoor use.

V. Economic Impact Models

The theory underlying our models is that economic activity, be it by the government or the private sector, has direct, indirect and induced effects. Direct effects, of course, refer to the impact on jobs and income directly resulting from the change that we are investigating. In other words, the purchase ofwireless equipment and of services from engineers and other technicians has an immediate effect of creating jobs and boosting income for those individuals whose goods or services are being purchased. Indirect effects are those that occur to businesses that deal with the beneficiaries of direct effects. Induced effects, on the other hand, can be thought of as “spillover” or “ripple” effects. This can be best explained by illustration: When BMW opened its facility in Greer, South Carolina, it created a large number of relatively high-paying jobs – this was the direct effect. The impact to the local economy was not limited to these direct effects, however. The workers hired into these new jobs spent most of that income on goods and services in the local economy; for example, they shopped at local stores and dined in local restaurants. This led in turn to the creation of more jobs and an increase in income for these businesses and those employed by them – these were the indirect effects. Like ripples in a pond, these workers then spent their income ongoods and services, and so on, which led to growth in the local economy overall. These are the induced or “spillover” effects. In this way, a boost to one sector of the economy can generate an increase in local income that is greater than the initial increase. These effects are taken into account in the following models. Themodels also consider impacts resulting from improved amenity values generated by the presence of ubiquitous wireless Internet, as described earlier.

The models were run using the Regional Dynamics (REDYN) modeling engine. REDYN is an Internet subscription-based Input-Output (I/O) and Computable General Equilibrium (CGE) modeling engine that forecasts economic and fiscal impacts of changes in various economic factors. The model utilizes the most current data available in order to forecast a baseline level of activity within over 800 Standard Occupation Classification (SOC) and 703 North American Industry Classification System (NAICS) sectors. Changes to employment, income, or demand for products or services by either the private orthe public sector can be inputted to the model. Based on these inputs, the model generates an estimate of the resultant variation from the projected baseline due to direct, indirect and induced effects, as well as the effects on every industry resulting from changes in prices of inputs and relative profitability of the industry. This output can be broken down according to effects on a number of indicators, including state output, employment, income, and tax revenue. The national REDYN model is available through the Strom Thurmond Institute.

The inputs used in our model, presented in Tables 1A and 1B, include the cost of equipment and services in constructing a wireless Internet network and maintaining it for 15 years after its construction.[13] Themodel assumes a network consisting of a mixture of

[13] Cost figures were obtained from Excelsio Communications, Inc.; these numbers fell roughly within the middle of the range of those we obtained in our research of projects currently being carried out in the

Wi-Fi mesh technology in urban areas and WiMAX technology in rural areas. The number of users covered by each technology is estimated using 2000 Census data indicating that 40 percent of the state's population live in rural areas, while 60 percent live in urban areas; the number of households covered by WiMAX in our models is therefore 40 percent of all projected users and Wi-Fi covers 60 percent. Simulations were run for two basic business models:

1. State government bears the full cost of constructing and maintaining the network, and
2. State government leverages its tower assets and directly bears only the cost of foregone revenue from rental of tower space for transmitters.[14] Private firm(s) finance other costs for construction and maintenance of network.

In each of the following simulations, the coverage by WiMAX was assumed to be 60 users per radio unit and coverage by Wi-Fi units was assumed to be 20 users. Based upon these assumptions, the number of WiMAX units needed to cover the state's rural population was 11,041 and the number of Wi-Fi units needed for the urban population was 33,124.[15]

Model inputs also took into account expected revenues generated by the wireless network. These revenues were estimated assuming a15% penetration rate for the network among households – that is, 15% of households in the state will utilize the network – and 77% among college students.[16] Revenue from these users is assumed to be $20 per household per year; built into this is the assumption that access will be given free up to a certain level of service with paid subscription rates at higher levels of service.[17] Note that revenues that might accrue from advertising allowed to be displayed to users of the free service was not included; if advertising is allowed, this would further offset construction and maintenance costs. In addition to revenues, other benefits of ubiquitous wireless Internet were considered, including cost savings to local governments due to increased efficiency and travel cost savings to households due to teleworking.

Efficiency savings to local government were based upon an assumed one hour per worker per week additional productivity for police officers and codes inspectors due to a reduced need to return to the office or headquarters to file reports. These estimates are likely conservative. The amount spent on police salaries was obtained from the US Department

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region and across the nation. These numbers are intended to be approximate, however. These costs, like all technology-related costs, are highly variable over time, and tend to come down as technology improves.

[14] This opportunity cost will be minimal due to the small amount of space likely to be occupied by the WiMAX base units.

[15] Note that these figures do not take into account networks already in existence, so the actual number needing to be constructed may be somewhat lower.

[16] Penetration among college students was accounted for by figuring the percentage of the population currently enrolled in college (assuming each student is associated with a single household), multiplying this number by 77% and adding the product to the penetration rate for households. Mathematically: 12% x 77% = 9.25%. This resulted in a household penetration rate of 24.25%.

[17] The typical rate cited in our sources for base paid services was $20. Premium services, such as for businesses, are more costly. Including free access for some users, we assumed that this averages out to around $20 per user per month.

of Justice.[18] Savings to municipalities from replacing T1 or DSL lines with wireless Internet access were also included in this figure.[19]

Table 1A – Model Inputs: Costs

Category	Wi Fi (Urban)	WiMAX (Rural)**	Total Cost
Costs:			
Equipment*	$92,284,260	$379,823,236	$472,107,496
Engineering	$10,892,044	$88,330,985	$99,223,029
Annual Operation and Warranty	$12,299,935	$88,330,985	$100,630,920
Total of Costs	$115,476,239	$556,485,206	$671,961,445

* Per unit costs for Wi-Fi, $2,517; for WiMAX, $60,000. Also includes allowance for backup units of 15% for Wi-Fi and 33% for WiMAX.
** Based on assumed capacity of 60 users per WiMAX radio unit.

Table 1B – Model Inputs: Usage and Savings

Category	Amount
Number of Users	662,482
Annual Revenue	$158,995,773
Annual Travel Cost Savings (Teleworking)	$60,902,376
Annual Efficiency Savings (Public Services)	$2,111,461

Travel cost savings due to teleworking was computed using Census data on time spent commuting. Currently, Census data indicate that 2.1 percent of workers work from home (which includes, but is not limited to, teleworkers). Assuming onemile per minute and 22.1 cents per mile, these savings were averaged across all commuters with the assumption that an additional 2.1 percent of workers will begin working at home with ubiquitous wireless Internet. This savings estimate may be conservative, as it is likely that those most likely to take advantage of telecommuting for example are those who travel the furthest to work every day, which would result in substantially greater cost savings. Also included in household savings is the reduced cost to households that chose to utilize the wireless network due the lower subscription rates for wireless services relative to DSL.

Following is a summary of each of the models run and their findings. Each simulation assumed construction of the network begun and completed in calendar year 2008 with equipment replacement necessary on average of every five years thereafter. Equipment replacement costs are divided evenly per year after the first year, in order to account for the likelihood that not all equipment will require replacement at the same time. These replacement cost numbers are somewhat pessimistic because equipment costs for WiMAX and Wi-Fi are both likely to come down over time as technology continues to improve.

[18] http://www.ojp.usdoj.gov/bjs/sandlle.htm#operating
[19] Assuming a $42 per month cost per T1/DSL line and an average of three lines per municipality.

Note that the model output presented in the following represents changes from the projected baseline in the indicated years. The baseline is the predicted level of each economic indicator based upon the latest available data, assuming that no changes to the economy occur beyond normal growth. The numbers presented in the tables are therefore additions or subtractions from this baseline resulting from the impact of the project on the state's economy.

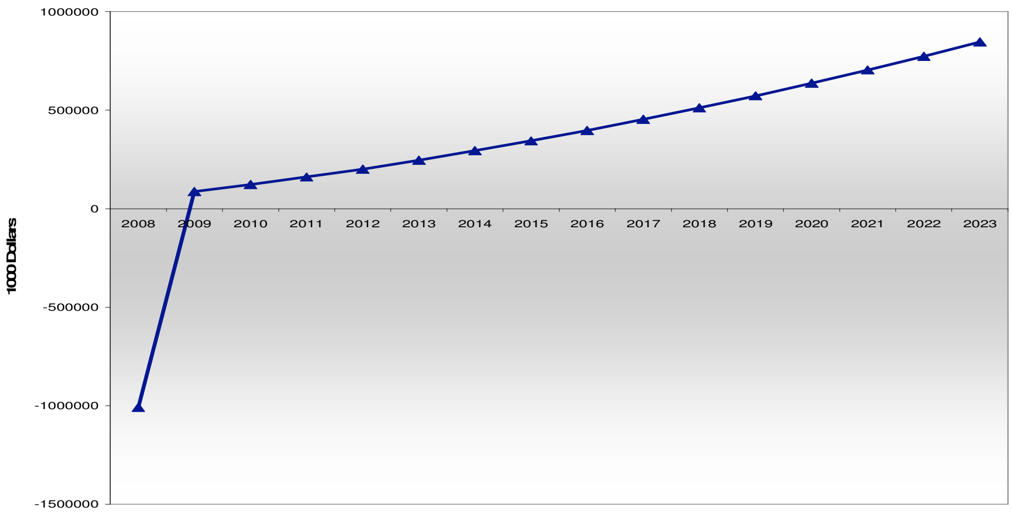
A. Model 1: Public Venture

The first model run estimates the economic impact of aubiquitous wireless cloud that would be entirely financed and maintained using state government funds. The model assumes that money used by the government to construct and maintain the network is funding diverted from other programs or services, as the model did not include any additional revenue from tax increases and did not take any possible budget surpluses into account. Because of this, the initial impact of this shift in government resources shows a large negative economic impact in the first year of the project. However, spillover effects from the network cause Gross State Product (GSP) to begin increasing over the projected baseline trend in the second year. Table 2 presents the net change in GSP and per capita disposable income, cumulated across the study period. For example, in 2018, $1.8 billion is predicted to have been added to GSP in total over the first ten years of the project. Figure 1 shows the predicted annual changes in GSP. The annual changes in GSP and per capita disposable income are also presented in Table 4 in Appendix 1. Per capita disposable income follows the same trend as GSP. Job creation in this scenario is predicted to be modest relative to the public-private venture to be presented next; this public venture model predicts an estimated net total of 933 jobs statewide by 2018.

Table 2 – Net Economic Impact – Public Venture (Cumulative)

Category	2013	2018	2023
Gross State Product	-$191.14 million	$1.81 billion	$5.34 billion
Disposable Income (per capita)	-$51.18	$142.67	$445.49

Figure 1 – Annual Change from baseline (GSP) – Public Venture



B. Model 2: Public-Private Venture

The second model examined a scenario in which the state government provides tower space for the mounting of WiMAX and Wi-Fi radio units and a private firm or firms finance the construction and maintenance of the network. This scenario is very relevant due to the fact that a number of South Carolina municipalities are currently either being served by aprivately-owned wireless network to some degree or are under consideration. These cities include Anderson, Charleston, Columbia, Greenville and Rock Hill. Other smaller municipalities are under consideration for privately-owned wireless networks as well. In nearly all of these locations, the technology employed or expected to be employed is Wi-Fi mesh. It therefore appears feasible that more urbanized areas are already attractive to wireless providers, making it less important for the state to provide funding to attract such development. In addition, the leveraging of state-owned tower assets would lower the cost to private firms to construct the rural WiMAX network.

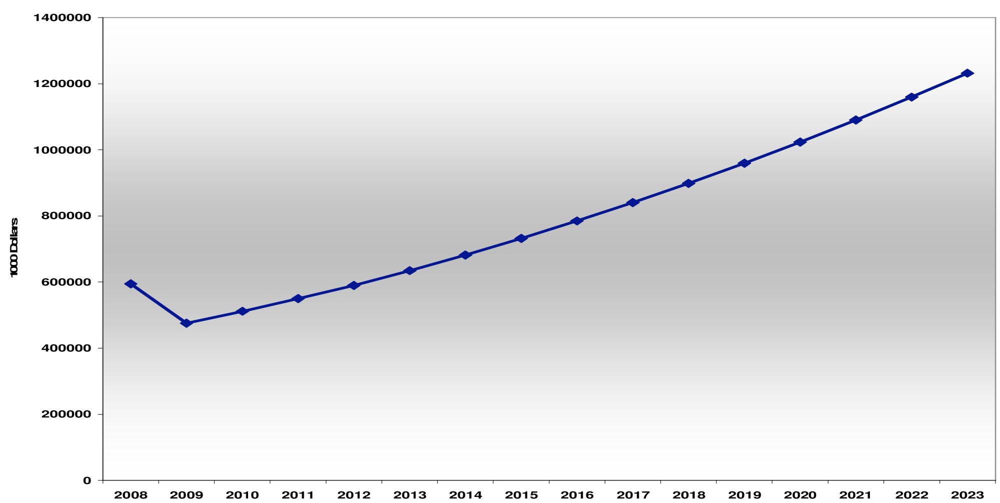
The effects on GSP and per capita disposable income are presented in Table 3 and Table 5 in the Appendix. Effects on GSP are presented graphically in Figure 2. Note that this model does not show the negative impacts on the economy in the first year seen in the previous model. This is because, while state government funding is limited by tax revenues gathered from the state's own tax base, private firms have access to venture capital from within and without the state. In other words, the state government financing models assume that the costs of construction would be diverted from other spending programs, resulting in cuts in those areas. Private firms, however, to the extent that resources might need to be diverted from other ventures, unlike the government have the option of diverting those resources from operations in other states or even other countries. For this reason, job creation is predicted to be more robust in this model, with an estimated average of 4,800 jobs created per year between 2008 and 2013. Note that the growth in GSP dips in the second year in Figure 2, which is due to the large surge in demand for goods and services created by the initial investment in the first year, but then expands in subsequent years as indirect effects on the economy grow. Nonetheless, the effect on GSP is positive in each year.

Table 3 – Net Economic Impact –Public-Private Venture (Cumulative)

Category	2013	2018	2023
Gross State Product	$3.36 billion	$7.29 billion	$12.76 billion
Disposable Income (per capita)	$345.07	$705.17	$1,164.17

One important consideration when using a business model that involves private firms is that, in order to maximize benefits, the wireless network needs to be compatible across systems. For example, the wireless network should be such that a tourist or business person can use his or her laptop to access the Internet in Columbia or Charleston without being required to reconfigure to a different set of technology. If this is not assured, much of the amenity value of ubiquitous wireless access would be lost.

Figure 2 – Annual Change from baseline (GSP) – Public-Private Venture



VI. Conclusion

Based upon the simulations presented in this study, it is clear that the type of business model chosen is extremely important to the success of this endeavor. Will the network be constructed and maintained by private or public interests? Who will own the network and be responsible for financing its operation?

The purely public model carries the advantage of giving the state greater influence in the planning and implementation of the wireless network and the stream of income from subscribers to partly recover the costs. What must be taken into account, however, is whether the state would be a suitable operator for an entire wireless network. Would the state be prone to keep pace with changes in the technology over time as would a private firm motivated by profit? One option is that the state carries the cost of construction, but allows a private firm or firms to contract for the operation of the network. This would, however, reduce the state's ability to recover its costs, as the private firm(s) would of course share in the revenues. Nonetheless, the first year impact on the state economy is predicted to be negative because of the diversion of government spending from other areas.

The public-private model carries the advantage that private firms bear the cost of construction. As a number of private firms are already considering or even constructing wireless networks in several municipalities, the private sector appears willing to enter the market. This model allows the state to reduce the cost borne by private developers by providing access to state-owned towers, increasing the incentive for private network construction in rural areas where the costs of development are much higher. Since the investment comes from the private sector and therefore does not require the reallocation of government resources, there is no initial negative impact on the state economy and the net increase in income is greater in each year.

In addition to the question of who will bear the costs of construction, the question of whether the network will provide free access to users below a certain level of service – and will advertising be allowed on the free service – or if the network will be available only by paid subscription must be addressed. Some of the business models we have seen in our research offer free service with advertising up to the 500 kilobit bandwidth, for example, then charge subscription fees for amegabit or greater bandwidth without advertising. Higher subscription rates could be charged to business users for higher bandwidth. This type of business plan assists in bridging the "digital divide", thus enhancing the network's amenity value – to residents as well as to tourists. Advertising also provides an additional source of revenue that could possibly more than offset the cost of providing a free service.

Each of these factors will need to be considered in order to determine what will be in the state's best interests in constructing awireless network. The economic impact of the network heavily depends upon which option is chosen.

Appendix 1

Table 4 – Annual Economic Impact – Public Venture

Concept	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GSP (x1000)	-1,008,018	86,568	122,696	160,769	200,845	245,997	293,753	344,161	397,263	453,093	511,682	573,053	637,227	704,216	774,027	846,664
Per Capita Disposable Income	-156.11	15.43	17.99	20.72	23.62	27.17	30.86	34.68	38.64	42.72	46.94	51.29	55.76	60.42	65.21	70.13

Table 5 – Net Economic Impact – Public-Private Venture

Concept	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GSP (x1000)	594,494	475,562	511,660	549,729	589,821	634,600	681,990	732,040	784,792	840,283	898,543	959,597	1,023,464	1,090,157	1,159,685	1,232,049
Per Capita Disposable Income	64.04	51.13	53.44	55.99	58.70	61.78	65.00	68.36	71.88	75.53	79.33	83.26	87.34	91.64	96.09	100.67

Appendix 2
Municipal Wireless Networks (as of January 2007)

Place	Technology Used	Construction Cost	Fee Structure
Gathered from our research:			
Charleston, SC (Private initiative)	Wi-Fi	$500,000 (Currently in planning stages)	Free access @ 500K with advertising Fee-based for greater bandwidth
Portland, OR	Wi-Fi mesh with WiMAX backhaul	$1,800 per Wi-Fi radio unit (under construction)	Free with advertising $20/month ad-free
Rhode Island (statewide)	WiMAX backbone with Wi-Fi mesh user interface	$120,000 per WiMAX radio unit (in pilot phase)	
Hart County, GA	Wi-Fi mesh	$57,500 per square mile covered (grant proposal denied)	
Decatur, GA	Wi-Fi mesh	$2,367 per radio unit $1,000/month maint. (proposal accepted)	$20/month (1 Mbps)
Newberry, SC	Wi-Fi mesh	$787,055 (proposed)	
Philadelphia, PA (Earthlink)	Wi-Fi mesh	$75,000 per square mile covered (in early phases of construction)	$20/month
Rock Hill, SC	Wi-Fi mesh (Tropos)	$3.4 million (33 square miles)	Free access in limited "hotspots" Primarily used for government services
SC Municipality (Private firm - proprietary)	WipLL (WiMAX variant)	$39,600 per radio unit (in pilot phase)	
Silicon Valley, CA (Public-Private alliance)		(Accepting RFPs)	Percentage of revenue returned to Alliance to fund operations.
From Research Reports International:			
Allegany County, MD	(Technology not specified in report)	$4.9 million	Access given to local Internet Service Providers (ISPs)

Place	Technology Used	Construction Cost	Fee Structure
From Research Reports International (continued):			
Houston County, GA		$702,000 first year, $340,500/ year recurring	Cooperative wholesale: ISPs deliver services
Chaska, MN		$600,000 nodes $100,000 fiber lease $100,000 services	$60/month (1 Mbps)
Cerritos, CA (Airmesh)		$600,000	$40/month residential $300/month business
Grand Haven, MI (Ottawa Wireless)		$40,000/square mile	VoIP starting at $20/month; Internet fees: $15/month (100 kbps) $45 (512 kbps)
Buffalo, MN (Wireless Internet Group)		$750,000	$16/month residential $40/month business (plus cost of antenna)
Nevada, MO		$40,000	$35 to $120/month
Vivian, LA (Fastline Internet)		$13,500 equipment $14,500 services Annual costs: $2000 maintenance $650/month T1 lease $129/month DSL backup	$10/month (64 kbps) $60/month (Mbps)
Linden, TX (Fastline Internet)		$9000 equipment $1000 annual maintenance $750/month T1	$10/month (64 kbps) $60/month (Mbps)
Scottsburg, IN		$384,000	$35/month (512 kbps) $200/month (1.5 Mbps)
Waupaca, WI		$100,000 tower $320,000 loan for deployment	$40/month, $99 installation
Marion, IN		$12,000	Free
Island Pond, VT		$125/month T1 lease $50-70,000 equipment and installation	$30/month residential $130/month commercial
St. Cloud, FL		$900,000 equipment $300,000 services $260,000/year maint. $40,000/year backhaul	Free

Place	Technology Used	Construction Cost	Fee Structure
From Research Reports International (continued):			
Granbury, TX	(Tropos uses Wi-Fi mesh technology)	$240,000 for 80 Tropos nodes $10,000 services $3,000/year maint.	Starting at $39.95/month
Lompoc, CA		$1.7 million	$19.99/month $4.99/day
Hermosa Beach, CA		$75-85,000 $18,000/year maint.	Free
Cupertino, CA (MetroFi)		$5 million	$20/month
Monticello, FL		$226,000 $2000/month for bandwidth	$29.95-39.95/month
Milwaukee, WI (Midwest Fiber Networks)		$20 million	$20/month