LONG-TERM ECONOMIC IMPACTS OF USDA WATER INFRASTRUCTURE INVESTMENTS IN OKLAHOMA

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CHAPTER I

INTRODUCTION

For a number of decades, the United States Department of Agriculture (USDA) has implemented a broad mix of support programs aimed at the development of rural America. Many of these efforts are heavily focused on providing infrastructure to rural areas, with distinct programs to assist in building rural housing, developing high-speed telecommunications networks, or aid in the construction of public water / sewer utilities. Their ultimate goal is to combat several factors that continue to plague rural areas, such as poverty and unemployment, population decline, and the isolation of rural residents. Thus, an underlying assumption of these USDA Rural Development programs is that the provision of infrastructure will have positive economic impacts on the rural areas in which they are implemented over either the short or long term.

The economic literature typically defines infrastructure as large, capital intensive natural monopolies such as highways and other transportation facilities, water and sewer lines, mass transit, and communications systems; with the majority of them publicly owned. Further, most of the publicly owned infrastructure funding comes from state and local government sources as opposed to federal funds.

Combined with the fact that investments in infrastructure are often highly visible to the general public, state and local policymakers have historically been very interested in providing public infrastructure as a means of regional economic development.

Infrastructure capital is just like any other capital in that it is purchased on the market at the time when construction or installation took place; however, it is rarely ever sold. This lack of sale is the reason why economic rates of public infrastructure depreciation are almost never directly measured (Gramlich, 1994). With shrinking government budgets and a need to demonstrate program effectiveness, programs that heavily invest in public infrastructure must develop ways of documenting their contributions. The economic literature clearly recognizes the fact that providing infrastructure by itself creates a short-term economic impact as construction and related spending take place; however, empirical investigation into the long term economic impact of such investments, particularly in rural areas, is lacking.

Therefore, an overarching question for the USDA Rural Development program is whether investments in rural infrastructure have a long-term economic impact on rural communities. In particular, do these investments impact population growth, poverty levels, income measures, or housing values among the rural residents that receive them? This study aims to answer this question using community-level data from a single state (Oklahoma) and information on which communities received funding from one particular USDA infrastructure (water and sewer) program during the period 1990 – 2000. Two distinct econometric techniques are used to assess whether receiving funding impacted a variety of economic growth measures over both the short (less than 10 years) and long (10 – 20 years) terms. The specific objectives of this study are to:

i. Determine whether economic growth has occurred in the areas which receive rural development water infrastructure funding,

ii. Uncover the short and long-term relationship between water infrastructure program investment and different measures of economic growth,

iii. Identify whether the water infrastructure projects implemented actually caused different types of economic growth over the short and long term.

Simple descriptive statistics and t-tests on eight different economic growth measures between communities that received / did not receive water infrastructure funding will be used to assess goal i). Multivariate regression analysis is used for goal ii), with eight economic growth measures as dependent variables and a host of potentially influential independent variables that includes a dummy variable for being a recipient of a rural development water / sewer infrastructure project. This technique allows for identification of whether the rural development projects significantly impacted economic growth after controlling for other observable characteristics, and over what time frame these impacts are observed. Goal iii) requires moving beyond regression to identify whether the *cause* of the growth is the water infrastructure projects implemented. To assess causality, a nonparametric technique known as the average treatment effect method is used. This involves incorporating a propensity score matching technique that looks at differences in the growth rates between places where funding was provided and places with similar characteristics, but no funding.

The text of this study proceeds in 5 sections. The literature review that follows this introduction will demonstrate that only a limited number of studies have focused on the economic impact of public infrastructure in rural areas, and none of them uses multiple econometric techniques to test the robustness of their findings. Section 3 lays out the methodology and data used, including basic descriptive statistics. Section 4 discusses the results of the two econometric techniques, and Section 5 concludes.

CHAPTER II

REVIEW OF LITERATURE

The importance of infrastructure to the growth and functioning of an economy is recognized in a wide variety of empirical economic research, suggesting that infrastructure is fundamental to economic development. Regions that lead in economic development usually have better physical infrastructure. Having this in mind, it is easy to understand why infrastructure development and special needs programs[1] account for more than 90% of the rural development funding provided by USDA (Blanford, Boisvert and Davidova 2008). One more fact that goes along with this line of thought is that investments in infrastructure are often highly visible to the general public (a new road for example), and are therefore more politically attractive.

The economic literature defines infrastructure as the services drawn from the set of public works that are supported by the public sector, even though it can be provided by the private sector too. Some researchers define infrastructure as the stock of capital that supports basic services fundamental to economic development. It includes investments in roads, streets, bridges, water treatment and distribution systems, sewerage, solid waste management, transportation, electricity, and telecommunications - facilities that are basic for the growth and functioning of an economy.

[1] Special needs programs are defined by USDA as those designed to provide individuals and communities with some level of basic services such as housing, sanitation or healthcare.

According to Fox and Porca (2001), investments in infrastructure can attract additional resources to rural places and rural economies thus making them more productive. However, there is little long-term analysis that backs up this claim. Typical multiplier-analysis of the USDA rural development programs designed to uncover the economic effects of these programs is focused only on short-term impacts, and there are no analyses that capture the long-term economic impacts of these programs. This is the case mainly because of the lack of reliable measures of local public capital stock (Duffy-Deno and Eberts, 1991). Having this in mind, the main objective of this research is to identify whether one particular type of rural development investment aimed at providing water supply and sewage systems impacts in long-term economic growth measures (increase in population, their income and earnings, decrease of people living in poverty, etc.) in the cities where the infrastructure is installed.

The majority of the empirical research on this topic set their focus on transportation and telecommunication projects, highway networks, airports, sewage treatment plants and water distribution facilities. While most studies focused on the economic impact of such projects in metropolitan and more densely populated areas, only a few studies deal with small infrastructure projects and their impact on rural economies.

In recent decades, providing public infrastructure as a way for regional economic development has been of great interest to local and state policymakers. At the same time, economists have begun to assess the economic effects of provided infrastructure on the region's economic development not only within the timeframe when construction takes place, but in the long run too. Table 1 provides a summary of previous studies on infrastructure impact and economic growth, including those that found a positive impact on growth and others that found only a small or negative impact. The remainder of this section will discuss these studies in more detail.

Table 1. Previous Studies on Infrastructure and Economic Growth

Study	Type of infrastructure	Focused on (areas)	Dependent variable	Significant results/findings
		Studies that found positive impact		
Aschauer (1989)	public capital investments	Metro and non-metro	output per unit capital, and total factor productivity of non-military public capital stock	increase in public capital investments of $1 billion, would result in anywhere from $1 to $1.5 billion in private investments
Gramlich (1994)	public infrastructure capital	Metro and non-metro	productivity rate	shortage of infrastructure should be avoided, by (1) reform the present system of financing infrastructure investment, forcing states could to bid for costly, large-scale high technology projects; (2) federal grants could be restructured and used less intensively
Eberts (1990)	roads, streets, bridges, water treatment and distribution systems, irrigation, waterways, airports, and mass transit	Metro	summarized findings from previous research (different variables)	public capital stock makes a positive and statistically significant contribution to manufacturing output

Fox and Porca (2001)	highways, electricity, telecommunications, water & sewer, roads, bridges	Metro and non-metro	summarized findings from previous research (different variables)	(1) positive effect on both entrepreneurship and firm decisions on where to locate; (2) expanding the use of existing resources; (3) attracting additional resources to rural places; (4) making rural economies more productive; (5) the expansion of the existing facilities or networks is more likely to result in only modest effects on rural economic performance
Chandra and Thompson (2000)	interstate highways	Non-metro	(1) population; (2) total earnings; (3) manufacturing earnings; (4) retail earnings; (5) government earnings	(1) significant positive effect on the construction industry during the period of new interstate highway construction; (2) economic activity moving away from adjacent counties to highways counties
Jiwattanakulpaisran et al. (2009)	highways infrastructure	Metro and non-metro	employment and highway correlation	highway construction exercised both positive and negative spillover effects on state employment growth, net employment effect is negative

Deno (1988)	highway, sewer and water public investments	Metro	profit function of: (1) public capital stock in roads, highways and bridges; (2) storm sewers and sewage facilities; (3) water supply and treatment	highway, sewer and water public investments have a strong positive effect on the supply side of the firm's manufacturing output. Water and sewers have the largest effect in expanding regional, highways have the largest effect in declining regions.
Bagi (2002)	water and sewer investments	Metro and non-metro	descriptive statistics on employment, income, property tax base, private and public investments	(1) rural and urban water/sewer projects both generate much greater economic benefits than their total construction cost; (2) create additional jobs, generate private investment, attract additional government funds, and increase the property tax base; (3) most urban projects experienced larger economic impacts than rural projects
Borcherding and Deacon (1972)	education, police, parks, hospitals, fire protection, highway and water-sewer public expenditures	Metro and non-metro	ratio of total payroll to total outlay (labor's share in examined 44 state during the year 1960-64)	large and statistically significant income elasticities for highway and water-sewer public expenditures

Duffy-Deno and Eberts (1991)	(a) sanitary and storm sewers and sewage disposal facilities, (b)roadways, sidewalks, bridges and tunnels, (c) water supply and distribution systems, (d) public hospitals, and (e) public service enterprises such as airports and ports	Metro	per capita income; intergovernmental revenue; property tax rate; state tax liability; percentage of owner occupant housing; percentage of population below poverty line	positive and statistically significant effects on per-capita personal income
Adelaja, Hailu and Abdulla (2009)	"green" vs. "gray" infrastructure	Metro and non-metro	(1) average time to work (for gray infrastructure); (2) land, water, winter and climate index (for green infrastructure)	investments will attract population to places that upgrade both gray and green infrastructure, and create higher per capita income and jobs
Canning and Pedroni (2004)	communication infrastructure, paved roads and electricity generating capacities	Metro and non-metro	(1) GDP per capita; (2) paved roads per capita; (3) electricity-generating capacities per capita; (4) telephones per capita	infrastructure does tend to cause long-run economic growth, but there is substantial variation across different countries
Gabe and Abel (2002)	telecommunications	Non-metro	descriptive statistics on ISDN investments in metro and non-metro areas	major telecommunications carriers deploy considerably more ISDN infrastructure in metropolitan areas than in nonmetropolitan areas of the US

Ford and Koutsky (2005)	broadband infrastructure	Metro	county economic activity, and per capita economic activity	doubling in economic activity and sales in the counties where broadband is provided
Lehr et al. (2005)	broadband infrastructure	Metro and non-metro	(1) employment, (2) wages, (3) rent, and (3) industry structure or mix	broadband enhances economic performance and growth, and communities with broadband availability experience more rapid growth in employment and number of businesses
Mahasuweerachai, Whitacre and Shideler (2010)	broadband infrastructure	Metro and non-metro	(1) employment, (2) Income, (3) housing value, (4) poverty rate, (5) different sectors of the economy, (6) per capita crimes, (7) per capita social security benefits, (8) amenity score	availability of broadband access may not be a key factor in attracting new residents and population growth – particularly for rural areas
Shideler, Badasyan and Taylor (2007)	broadband infrastructure	Metro and non-metro	employment growth in different sectors	broadband infrastructure has a significant positive impact on a region's overall employment growth

Studies that found small or negative impact

Evans and Karras (1994)	government capital and services	Metro and non-metro	gross state product in all private nonagricultural industries	(1) fairly strong evidence that government educational services are productive; (2) no evidence that other government activities are productive; (3) productivity of gov't capital is negative

Holz-Eakin (1994)	public capital stock (roads, bridges, water-supply systems, sewerage facilities etc.)	Metro and non-metro	(1) private output; (2) private employment; (3) private capital; (4) public capital	the use of aggregated data did not reveal significant linkages between the provision of infrastructure and increase in private productivity
Holz-Eakin and Schwartz (1995a)	public infrastructure capital	Metro and non-metro	productivity growth	infrastructure investment have a negligible impact on annual productivity growth between 1971 and 1986
Holz-Eakin and Schwartz (1995b)	state highways	Metro and non-metro	spillover effects from highway capital accumulation	no evidence of quantitatively important productivity spillovers from state highways network
Holtz-Eakin and Lovely (1996)	public infrastructure capital	Metro and non-metro	productivity effects	indicate little contribution of public infrastructure to direct output in all sectors, except in the manufacturing

The studies in Table 1 that find a positive impact generally hypothesize that public infrastructure stimulates economic activity in two primary ways: by increasing the productivity of private firms, or as an unpaid factor of production. Private inputs are typically purchased in a free market; however public capital is provided by government and financed through taxes. Because of the fact that tax payments are not necessarily connected to the quantity of public capital used by private firms, public capital can be seen as an unpaid input to the firm's production process.

An early and influential contributor to the study of the impacts of public capital was David Aschauer. In one of his most cited studies, Aschauer (1989) introduces the idea grounded on the neoclassical theory that increases in public investment spending should act as a stimulus on private output. He argues that public investment creates an increase in the rate of return to private capital, resulting in private investments four to seven times large as public investments were in the first place. In his paper he considers the behavior of productivity in the entire private United States economy. By examining the productivity of public expenditures, Aschauer attempts to define the extent to which public expenditure policies can induce excess aggregate demand pressures, raise interest rates, and stimulate production. Results of his study unveil that 'core' infrastructure (i.e., streets and highways, airports, electrical and gas facilities, mass transit, water systems, and sewers) possess greatest explanatory power for productivity. Policymakers should give significant weight to this fact in their attempt to improve the overall productivity and efficiency of the firm's operating in a particular region. Aschauer states that core infrastructure raises productivity and value added mainly in sectors that directly benefit from public capital investments, such as transportation (see Table 1 – significant results/findings). The type of infrastructure found to be the most responsible for improving productivity are highways, widened or expanded roads, and improved water treatment and sewer plants.

Gramlich (1994) uses the definition for infrastructure that, as he states, makes the most sense from an economics standpoint. This definition consists of large, capital intensive, natural monopolies such as highways, other transportation facilities, water and sewer lines, and communications systems. Most of this public capital, around 88 percent of the buildings and facilities, and 71 percent of the equipment, is owned by state and local governments. Having this in mind, Gramlich argues that we can no longer describe problems with infrastructure as a federal government problem, but rather state and local ones. This puts more pressure on state and local economists who might have trouble recognizing infrastructure capital as a way for community development for one simple reason - these goods and services are not sold on the market, and therefore their effect cannot be measured easily. Infrastructure capital, just like any other capital is purchased on the market at the time when construction or installation took place, and it is rarely ever sold. This lack of sale is the reason why economic rates of public infrastructure depreciation are almost never directly measured.

Increased productivity as a result of adequate infrastructure availability was the main concern in Eberts' (1990) study. He summarizes findings from previous research concerned with infrastructure provided mainly in the metropolitan statistical areas of the United States. His summarized results imply that public capital stock in the form of public infrastructure investments had a significant effect on regional economic activity. Defining infrastructure as public capital investments that make private capital investment more productive, he states that if a local or state government provides the necessary facilities, then private firms do not need to construct their own. In this way, infrastructure can be viewed as a direct input into a firm's production process. This means that an increase in the level of public inputs will result in increased output for all firms in the region by the same amount or by the same amount of increased efficiency of their operations. Therefore, any firm entering that region will benefit from the existing level of public input, at the same time not affecting the public input benefits received by the other firms. Furthermore, infrastructure can enhance a region's amenities, attracting households and firms to a particular area, thus contributing to economic growth. He concludes with the notion that "public capital stock significantly affects economic activity" (Eberts, 1990, p.25), suggesting that the existence of public infrastructure is a necessary precondition for regional economic growth.

On the same line with Eberts are Fox and Porca (2001). By investigating the role of infrastructure in a prosperous economy, they note that providing water, electricity, telecommunications, and other infrastructure are of paramount importance to business development. Fox and Porca attempt to answer whether infrastructure investments must be used to stimulate economic growth, or, on the other hand, whether infrastructure should simply be expected to accommodate growth that is otherwise occurring. Ultimately, they found that infrastructure has a positive effect on both entrepreneurship and firm decisions on where to locate, both important measurements of economic development. Investigating the building of new capital and also the expansion of existing capital infrastructure facilities in the rural areas, their suggestion is that investments like this are influencing rural economic performance in three ways: (1) by expanding the use of existing resources, (2) attracting additional resources to rural places, and (3) making rural economies more productive. Several economic benefits can be expected from such investments, including an increase in the productivity level of the businesses operating in the region, more intensive and efficient use of resources, and the potential attraction of additional resources due to the existence of more productive business. On the other hand, lack of adequate infrastructure can lower a firm's productivity. Recognizing the short-term or temporal economic stimulus as construction of new infrastructure take place, they also expect an increased long-term derived demand from the surrounding rural economies when infrastructure is available for use. They also add that infrastructure can attract other productive inputs to the region, attract new firms, and offer employment opportunities from the increased level of economic activity. In addition to being a direct input into a firm's production process, infrastructure may attract new households to locate in the area. Many of these households may be ready to accept lower wages due to the bundle of amenities (including infrastructure) offered by the community. However, the overall conclusion drawn by this study is that if providing infrastructure is followed by increased economic development, the expansion of the existing facilities or networks is more likely to result in only modest effects on rural economic performance. Fox and Porca's findings about the economic rate of return of the infrastructure, which is generally low for new investments (a new road for example) and even negative for expanding the existing roads, is diametrically opposite from Aschauer's (1989) findings. Aschauer found that infrastructure is extremely productive, and can pay for itself within a year. Fox and Porca conclude with the opinion that infrastructure is essential to accommodating growth, but it is not a sufficient condition for stimulating self-sustaining growth that would not occur in the first place.

Chandra and Thompson (2000), in their empirical assessment of whether large infrastructure spending (i.e., interstate highway construction), has an impact on economic growth, found a significant positive effect on the construction industry during the period of new interstate highway construction (1969 through 1993). They choose to study highways because of their important role in public sector investment, and because highways are a frequent subject in the theoretical literature on economic growth. Their research interest is built upon the assumption that the building of a new highway is an exogenous event, and therefore has no relation to the economic growth experienced in the past. Their hypothesis says that providing a new highway in a region will result in a different impact across industries. One type of industry will grow as a result of decreased transportation costs, while others will experience a decrease in their economic activity, and relocate in other areas. The authors set their focus on non-metropolitan counties who often receive an interstate simply because they fall on the route between cities to be connected with a new highway. The primary analysis focused on the level of economic activity that highways create in the counties that they pass through, while at the same time drawing economic activity away from adjacent counties. Thus, these types of highways had a dual effect on the level of net regional economic activity. Their results show that the construction of new interstate highways increases total earnings in counties where they pass through, and decrease earnings in counties adjacent to highway counties. The dual effects of economic activity moving away from adjacent counties towards counties with highway infrastructure and the intra-county reallocation of industrial capacities lead to rearrangement but not necessarily to an increase in economic activity on a regional scale. Highway-counties experienced an increase in earnings in the manufacturing, retail trade, and services sector. Only earnings in manufacturing sector were found to be increasing in counties adjacent to highway counties, as a result of the construction. At the same time, a reduction in retail trade and government earnings was found in adjacent counties due to the highway's opening.

Similarly, Jiwattanakulpaisran et al. (2009) found counteracting results when examining the impact of increasing the density of interstate highways on aggregate county-level employment. Their results suggest that highway construction exercised both positive and negative spillover effects on state employment growth, and that the net employment effect is negative.

Deno (1988), in his study examining the effect of public capital on private production decisions, found that highway, sewer and water public investments have a strong positive effect on the supply side of the firm's manufacturing output. He further notes that public capital in water and sewer systems have a larger effect on the supply of manufacturing output in growing regions. This finding leads him to conclude that the production processes of the manufacturing firms that operate in growing regions are highly dependent on waste disposal and water treatment facilities. His second finding is even more intriguing. He finds that water/sewer and highway infrastructure have strong complementary relationships with private labor and capital in areas with declining economic growth compared to growing areas. His estimates indicate that in both growing and declining areas, investments in such infrastructure will increase employment in the basic sector, and through multiplier processes will lead to an increase in the personal income of all residents. Deno summarizes his findings by reiterating that public capital plays a significant role in manufacturing firm's decisions, and that sewer and water facilities are more important in growing regions compared to highways, which are more important in declining regions.

Probably the most in-depth research regarding the economic impact of water and sewage investments is performed by Bagi (2002). He examines the impact of 87 water and sewer projects included in the study, 54 of them located in urban and 33 in rural areas across 30 different states. All of the projects were financed by the Economic Development Administration (EDA), and built for specific firms or beneficiary or potential investors, who receive the direct benefits from such investments. Each grant recipient was asked to get local economic developers and other local officials to estimate the impact of the EDA funded projects. Indirect benefits are seen in the potential to attract new businesses that tap into the new water/sewage lines and operate, relocating and new businesses that make use of the increased capacity of the water/sewer lines, and retail stores and services that emerges as a result of increased economic activity, population and personal and family income. Results of the study revealed that water/sewer projects in the examined places can save and create additional jobs, stimulate private sector investment, attract additional government funds, and increase the property tax base. The primary difference between urban and rural projects was that the construction costs were higher (1.3 times on average) for urban than rural water/sewer projects. However, the average economic benefits to businesses were also larger in urban areas. Beneficiaries from the water/sewer projects in both urban and rural communities saw substantial employment increases, additional private investment, and public funds.

Bagi did find, however, that the economic impacts are typically larger in urban areas versus rural ones.

Deno's and Bagi findings are complementary to Borcherding and Deacon's (1972) findings. In their attempt to estimate the demand for local public expenditures and the effect of public capital stock on regional income, they found large and statistically significant income elasticities for highway and water/sewer public expenditures.

Similarly, a study based on annual data for 28 metropolitan areas from 1980 through 1984, Duffy-Deno and Eberts (1991) revealed that public capital stock has positive and statistically significant effects on per-capita personal income. According to this research, positive effects came through two channels (1) as actual construction of the public capital stock took place and (2) through public capital stock as an unpaid factor in the firm's production process and through consumption goods of households as well. Furthermore, the second effect was found to be twice as large as the first one. Results from this study show that the positive effect came not only as a result of construction activity related to the public capital, but also as an important input into the regional production process, uncovering long-run positive effects on a region's productivity, acting as a competitive advantage. This shows that well-designed and maintained public infrastructure is an important component of any effort and public policy for promoting regional economic development, particularly in metropolitan areas.

Adelaja, Hailu and Abdulla (2009) conducted research that aims at uncovering the key factor for economic growth in what they call the "new economy". They divide the infrastructure into two parts, referring to the traditional infrastructure (highways, airports, and telecommunications) as "grey", and introduce "green" infrastructure (in the form of land, water and climate amenities). They suggest that the “green” infrastructure will play in the key role in future regional growth. Their conclusions are derived from the fact that growth in population, income and employment are mostly synergistic and are increasing in areas where investments in “green” infrastructure are taking place. Nevertheless, their results predict that investments in gray infrastructure will not only attract population, but create more jobs and raise per capita income of the residents.

Some researchers have asked another very interesting question regarding public infrastructure. Accepting the premise that investments in infrastructure will result in a region’s economic development, they wanted to move forward and establish the optimal level of infrastructure expenditures on which the maximal growth rate will be achieved. Economic literature recognizes that infrastructure capital is a vital input into production, but resources are not limitless, and investment in infrastructure comes at the cost of reduced investment in other types of capital (Canning and Pedroni, 2004). This approach takes into consideration an optimal level of public infrastructure which maximizes the growth rate, and specifically looks to see if infrastructure levels that are set too high, both locally and regionally, will affect the rate of investment in other capital (ex. social capital) to the extent where economic growth suffers a reduction. Communication infrastructure, paved roads and electricity generating capacity were the focus of this research. The authors gave a look at broader geographical regions, such as different states on different continents, including the U.S. Their results show that, on average, telephones and paved roads are supplied at around the growth maximizing level, but some countries have too few while others have too many. However, they fail to provide details about which growing regions/countries have oversupplied or undersupplied levels of infrastructure. They also find that long run effects of investment in electricity generating capacity are positive in a large number of countries, and that negative effects were found in only a few, suggesting that electricity generating capacities may be under provided.

Recently, the impact of a new form of infrastructure – telecommunications – has been of great interest. Several studies on telecommunication infrastructure have showed positive impacts on economic output, and positive effects on employment levels. Gabe and Abel (2002) focused on the improvements in telecommunications infrastructure and came to the conclusion that this type of infrastructure investments contribute to lowering the costs of doing business, thus leading to increased economic output, ultimately increasing income and job creation. Nevertheless, according to Gabe and Abel, the high fixed costs of deploying advanced telecommunications infrastructure, especially in areas with low densities of economic activity, combined with the uncertainty about future technologies (DSL, wireless) are likely to decrease those types of investments in rural areas if at least some funding came from public sources.

Ford and Koutsky (2005) acknowledge the great importance cities and counties are beginning to recognize in the deployment and development of broadband infrastructure. They recognize that this type of infrastructure is potentially more important than other types of public infrastructure. They state that the future of a community in the twenty-first century is directly related to the community's public infrastructure, especially with broadband. The Bureau of Economic Advisors (Input-Output Accounts Data, 1999) states that broadband infrastructure displays a range of positive, public benefits on the economy, and the results of Ford and Koutsky provide support for such claims. Their results show doubling in economic activity and sales in the counties where broadband is provided, relative to other counties without broadband. This is also complementary to Lehr et al. (2005) who show that broadband does enhance economic performance and growth, and those communities with broadband availability experience more rapid growth in employment and number of businesses. Further, while Mahasuweerachai et al (2010) do not find any dramatic effects of early broadband provision on migration, they do find evidence that rural areas with two types of broadband infrastructure had significantly higher migration rates during the early 2000s. Also Shideler, Badasyan, and Taylor (2007), based on the results of their economic impact study on broadband deployment in Kentucky, conclude that this infrastructure has a significant positive impact on a region's overall employment growth. Therefore, broadband investments are another form of infrastructure, together with more traditional types that could offer higher economic growth to the community and other related benefits.

The numerous studies discussed so far displayed findings which support the concept that public capital stock in the form of public infrastructure are responsible for increased economic growth, productivity and employment. Many of these findings have been empirically confirmed. However, in a series of recent papers in which econometric assumptions have been challenged and criticized, some authors find little evidence of extremely positive spillover effects from public investments.

Evans and Karras (1994) in their study on the productivity level of government funded infrastructure found that besides public educational services, no other government activities had any positive impact on productivity. Instead, the evidence they found was negative and usually with high statistical significance.

Holz-Eakin (1994) used state-level and region-level data to indicate that the elasticity of output and productivity in private firms with respect to public capital (i.e. public infrastructure) is zero. In addition he asserts that it would be wrong just from one analysis to conclude that there are no benefits from provision of roads, bridges, water-supply systems, sewerage facilities and other infrastructure services, but the use of aggregated data did not reveal significant linkages between the provision of infrastructure and increase in private productivity.

Holz-Eakin and Schwartz (1995a), in their study on infrastructure accumulation and its implications on productivity growth, introduced a new neoclassical model of economic growth, to examine infrastructure implications on productivity rate. Stating that the link between infrastructure and productivity growth is controversial, and expressing their surprise for the fact that infrastructure research has developed in isolation from the large literature on economic growth, they find little support for claims of a dramatic productivity boost from increased public infrastructure investments. Employing a specification designed to provide an upper bound for the influence of infrastructure, their estimation showed that raising the rate of infrastructure investment would have had a very small impact on annual productivity growth in the private sector, in the examined period between 1971 and 1986. However, their analysis does not model the interaction between public infrastructure and private investment incentives, contributing to the conclusion of negligible impact of infrastructure on productivity growth.

In another study, Holz-Eakin and Schwartz (1995b) use a spatial regression model to examine the degree to which state highways provide productivity benefits beyond the borders of one particular state. They estimated spillover effects using state-by-state data for capital, labor and private-sector output, as dependent variables. Even though state highways and especially the interstate highway system are designed partly with interstate linkages, the authors were not able to find evidence of important productivity spillovers, and even more, none of the econometric analyses reported in their study suggest significant productivity spillovers. Their estimates confirm the absence of dramatic productivity effects found by other researchers, especially Aschauer.

Holtz-Eakin and Lovely (1996) examine the impact of public infrastructure on productivity levels of private capital. Particularly, their hypothesis suggests that the degree of monopoly power by the infrastructure provider influences public capital's productivity effect. The results of their empirical investigation indicate little contribution of public infrastructure to direct output in all sectors, except manufacturing. However, infrastructure does have an effect on the number of individual manufacturing establishments, indirectly increasing total manufacturing output.

Table 1 suggests that the research evidence on whether infrastructure induces growth or growth influences infrastructure has been mixed. Although many studies have found economic growth positively affected by public infrastructure provision, others have found limited evidence of productivity, and there is a considerable degree of consistency in that many studies find that the relationship is reversed or that it works in both directions.

Rodriguez (2010) provides a nice summary of these and other important papers in the literature and concludes that “on balance, the research is either far from conclusive or suggests that infrastructure investment does improve rates of growth.” (p. 13)

One can conclude that only a limited number of studies have focused on the economic impact of providing public infrastructure in rural areas. Most of the studies use aggregated macroeconomic data, identifying economic impact that infrastructure causes on national or even global level. In the absence of empirical studies that captures the long-term economic impact of small infrastructure projects in rural areas, this study will try to make a modest contribution by examining the relationship between USDA water infrastructure investments and their economic impact in a single state. Using historical data over the period 1990-2000, the impact of small public water supply and sewage systems provided to different rural communities is estimated, considering community-level economic outcomes (as opposed to private firm productivity) in Oklahoma, and looking distinctly at short versus long term impacts.

CHAPTER III

METHODOLOGY AND DATA

This research will attempt to answer the question of whether the Oklahoma communities that obtained USDA rural development investments in public water infrastructure experienced economic growth over the period 1990-2009 with two different econometric techniques: (1) multivariate regression analysis, and (2) the average treatment effects method. The two methods are distinct in their assumptions; comparing the two results will offer a way to test the robustness of their findings.

Chapter III also provides an overview of the conceptual framework associated with this project along with a more detailed description of the methodology and data used.

3.1 Conceptual Framework Overview and Hypotheses

As the literature review section has revealed, most empirical research suggests that infrastructure is fundamental to economic growth. Regions that lead in economic development usually have better physical infrastructure. The main hypotheses of this study are complementary to these statements.

> [H1]: To determine whether economic growth has occurred in the areas which receive rural development funding.

Taking into account the serious financial resources allocated and spent on water-supply and sewage projects, the main hypothesis is that a positive relationship between USDA water infrastructure investments and economic growth in the places where such investments took place will be uncovered. Simple descriptive statistics and t-tests between the two groups (with and without investments) will give an answer to the first specific objective.

> [H2]: To uncover the short and long-term relationships between levels of rural development program investment and different measures of economic growth (per capita income, median household income and earnings, poverty levels etc.).

The answer to the second specific objective will be found using multivariate regression. Employing this technique will allow for identification of whether the rural development projects significantly impacted economic growth, and over what time frame these impacts are observed. However, given the complexity of interaction between different factors that stimulate economic growth, it is not expected that all examined dependent variables will display a positive effect. Infrastructure investments should provide a suitable environment for doing business and attracting new businesses, at the same time creating conditions for more effective use of the existing resources like land, water, scenic scenery and other amenities. Such an economic environment may attract people to move in, resulting in population increase, housing construction and growth of the service sector, and may also have significant impacts on employment, income, and ultimately an improvement in the quality of life.

> [H3]: Identify whether the cause of the growth is the rural development projects implemented.

Regarding the third specific objective, the hypothesis is that investments in water and sewage infrastructure will lead to an increase in population and income, increase in housing construction and value of the houses, and reduction in the percent of rural residents living in poverty. To assess causality, average treatment effect methods are used. This involves incorporating a propensity score matching technique to determine causality in the eventual difference in the growth rate between places where funding was provided and other places with similar characteristics, but no funding. The next section provides more detail about the methods employed to test the hypotheses [H2] and [H3].

3.2. Ordinary Least Squares Regression

Identifying the economic impact created by the newly provided infrastructure poses several challenges that must be addressed. A typical economic impact analysis identifies the job creation and other related economic benefits associated with the growth of the local economy. The provision of infrastructure itself cannot create economic growth and sustained job creation, but only temporary jobs associated with construction or maintenance of the infrastructure. It is often difficult to predict how specific types of infrastructure will be utilized by different industries. In addition, the presence of the new infrastructure may also make the region attractive to new firms that will relocate, at the same time attracting more people to move in, and take advantage of the improved life conditions.

Having this in mind, economists often estimate the economic impacts of infrastructure using a modified growth model. The growth model is a methodology to predict a region's growth over time (Shideler, Badasyan and Taylor, 2007, and Lehr et al., 2005). This model predicts the economic growth of a region during one period based upon the level of economic activity of some previous period plus any compounded growth that would be expected to occur between the two periods. Mathematically, this process can be expressed as:

$$Y_t = AY_{t-i}{}^{\alpha}\, e^{\mathrm{ri}}$$

where: Y_t represents the economic level at time t,

A is a constant, α is a scaling parameter, and

e^{ri} is the formula for compounded growth at rate r for i periods.

The most important element in this approach is to determine the correct expected growth rate, r, between the two periods. Because of the importance of this step, the growth rate, r, is determined statistically using multivariate regression analysis. Transforming this growth equation using natural logarithms, assuming that A and α equal 1 (which are standard assumptions when empirically testing growth models), and defining time periods in such a way as to make i = 1, the following equation is derived:

$$ln(\frac{\mathrm{Y}_t}{\mathrm{Y}_{t-1}}) = \mathrm{r_t} = \beta_1\mathrm{X}_{1t} + \beta_2\mathrm{X}_{2t} + \beta_3\mathrm{X}_{3t} + \beta_n\mathrm{X}_{nt} + \gamma\mathrm{I}_t + \varepsilon_t \qquad (1)$$

Equation (1) states that the economic growth rate $\mathrm{r_t}$ is a function of the explanatory variables (X), dummy variable (I) and an error term ε. In the case of this research, the dependent variable (Y) represents eight distinct measures of economic growth: (1) population; (2) median household income; (3) per-capita income; (4) percentage of households with earnings; (5) percentage of households with self-employment income; (6) percentage of population living in poverty (under1.00 poverty coefficient); (7) percentage of vacant housing units; and (8) median housing value. The explanatory variables (X) includes a variety of socioeconomic factors i.e. (1) racial/ethnic characteristics of the population, (2) education levels (percent of population with different education levels), (3) mean travel time to work (15, 30, 45min, and 1 hour), (4) percentage of population included in the labor force, (5) households lacking complete plumbing facilities; (6) median year of structures built; (7) population density, (8) unemployment rate, and (9) RUCA codes[2]. The error term ε is assumed to have a log-normal distribution. An infrastructure dummy variable (I_t) is created by assigning a one (1) to all places that received public funding for the programs of interest, and zero (0) for the places that didn't receive any funding. Data for this dummy variable comes from the Oklahoma USDA Rural Development office, and is discussed in more detail in the data description later in this section. In particular, most important part is whether the infrastructure investments impacted growth, or whether $\gamma = 0$. Each of the eight dependent variables is regressed following the model stated above. The findings from two time periods are compared: the short-term (less than 10 years after implementation) and the long-term (10 – 20 years after implementation).

The presented model is similar to the one used in Lehr et al. (2005). If one takes Y to represent the economic activity, Lehr's framework can also be used to analyze the effect of public infrastructure on specific measures of economic growth (as the attempt is to do here), where change in economic growth is estimated through the various measures taken into account and a random error term.

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[2] The Rural-Urban Commuting Area (RUCA) codes are designed for measuring rurality (i.e., to define county-level metropolitan and micropolitan areas). They are often used as measures of population density, urbanization, and daily commuting to identify urban cores and adjacent territory that is economically integrated with those cores. We incorporate them as a proxy measure of distance from metropolitan areas (from 1 to 10; 10 being the most rural).

3.3. Average Treatment Effects

Previous research has shown that regression analysis can verify whether infrastructure investments are correlated with the measures of economic growth, but it cannot establish a firm causation. Regression imposes significant restrictions upon the analysis, in terms of a functional form which may have an impact on the conclusions drawn from its results. It is suggested that matching techniques could avoid these problems because they are model-unbiased and hence do not contribute to drawing restrictive assumptions (Mahasuweerachai, Whitacre, and Shideler 2010). Therefore, the average treatment effect (ATE) method is often used as a way to compare treatments (or interventions) in randomized experiments, evaluation or policy interventions. The ATE measures the average causal difference in outcomes between the treatment and the control groups. In a randomized trial (i.e., experiment), the average treatment effect can be estimated using a comparison in means (or medians) between treated places that received public infrastructure funding and untreated places that didn't. This method will allow for observation of the impact of public infrastructure programs 5 and 10 years after implementation by comparing them to statistically similar places that, as mentioned, did not receive funding.

To be able to measure the effect of completed projects on the different economic growth variables, the ATE focusses on the difference in the percent change in economic indicators between places where infrastructure was provided and where it wasn't. This will be the "treatment effect" because those areas with publicly funded infrastructure are considered to have been "treated." Therefore, we let ΔY_{t1} and ΔY_{t0} be the economic indicators of the areas at time *t* with and without public infrastructure funding provided, respectively. The average treatment effect (ATE) can be represented as:

$$ATE = E(\Delta Y_{t1} | \, I_t = 1) - \, E(\Delta Y_{t0} | \, I_t = 1) \quad (2)$$

where: ΔY_{t1} = growth in economic indicator at time t for treated areas (with infrastructure funding);

ΔY_{t0} = growth in economic indicator at time t for non-treated areas (no infrastructure funding);

I_t = 1 for areas with public infrastructure funding provided (treated), and 0 for areas without infrastructure funding provided (non-treated).

But, we want to assume that they both actually received infrastructure funding I_t = 1.

In an experiment or evaluation, both Y_{t1} and Y_{t0} can be observed (Lu, 2007). However, in this case either ΔY_{t1} or ΔY_{t0} can be observed for a particular place, but not both, since each community will have either participated or not participated in the USDA water-supply and sewage systems infrastructure program. Thus, each 'treated' community needs a comparable, non-treated counterpart. To accomplish this, we need to "match" communities that obtained the investment with otherwise similar communities that did not obtain the infrastructure. The first step in doing so is to estimate a propensity score – that is, the likelihood of obtaining an infrastructure project.

A considerable risk of self-selection into the treatment group is possible, which in turn can be a cause for biased estimates of the places where infrastructure is provided.

This problem is avoided by using the propensity score matching method to correct for self-selection bias due to observable differences between the treatment (places where infrastructure funding provided) and comparison groups (places without infrastructure funding). The process of matching involves pairing treated and comparison units, which are similar in terms of their observable characteristics (Dehejia and Wahba, 2002). Most applications in the statistics literature use a logit model to estimate this propensity score, where the conditional probability of obtaining an infrastructure project is modeled on observable predictors such as the socioeconomic variables included in the OLS regressions. Further on, an assumption of exogeneity or conditional independence must be applied in order for matching methods to yield an unbiased estimate of the treatment impact. This implies that there should be no unobservable differences between places with infrastructure provided (treated) and without (non-treated) after conditioning on observable characteristics. According to the assumptions drawn here, the economic growth rate in areas without infrastructure provided could represent what similar areas with infrastructure provided would have experienced if such investments were not made in the given place. The general literature refers to this process as the average treatment effect on the treated (ATET), and is expressed as:

$$E\ (Y_1 - Y_0|D=1) = E\ (Y_1|D=1) - E\ (Y_0|D=1) \tag{3}$$

The main part in this process is to construct the counterfactual $E\ (Y_0 \mid D=1)$, i.e. the potential outcome that, as mentioned, participants in water infrastructure projects would have experienced (on average), if they have not participated in the program (Sianesi, 2001).

Matching communities involves using a simple estimator and propensity score matching techniques, which have been widely used in many recent studies (Becker and Ichino, 2002; Hirano, Imbens and Rider, 2003) resulting in outcomes with unbiased estimates. The matching method assumes that the observable characteristics (X) (i.e socioeconomic factors in our case), will capture all relevant differences between the two groups we want to match:

$$Y_0 \perp D \,|\, X \tag{4}$$

The next step in this process is the selection of a control group from the pool of non-treated units, in a manner where the distribution of observable variables will be as similar as possible with the distribution of the observable variables in the treated group. To do this, the matching process needs to be performed over the common support region:

$$0 < Prob\{D{=}1 \mid X{=}x\} < 1 \text{ for } x \in \sim\mathrm{X} \tag{5}$$

Sianesi (2001), having in mind the equations (4) and (5), mathematically represents the propensity score matching as:

$$p(x) \equiv Pr\{D{=}1|X{=}x\} \tag{6}$$

$$Y_0 \perp D \mid p(X) \text{ for } X \text{ in } \sim\mathrm{X} \tag{7}$$

According to equation (6), we pair each treated place that received funding, with some group of comparable places that not have received funding, and then associate the outcome of the particular place with the ‘weighted’ outcomes of his ‘neighbors’ (closest match) within the comparison group:

$$\hat{y}_i = \sum_{j \in C^0(p_i)} w_{ij} w_j \tag{8}$$

where: $C^0(pi)$ is the set of neighbors of treated places in the control group;

$w_{ij} \in [0, 1]$ with $\sum_{j \in C^0(p_i)} w_{ij} = 1$ is the weight of the control j in forming comparison with treated place (i).

Rosenbaum and Rubin (1983) define propensity score as the conditional probability of receiving a treatment given pre-treatment characteristics. Shown in mathematical terms:

$$p(X) \equiv Pr\{T = 1|X\} = E\{T|X\} \quad (9)$$

where T = {0, 1} is the indicator of treatment effect, and X is the vector of pre-treatment characteristics. Rosenbaum and Rubin also show that if the exposure to treatment is random within cells defined by X, it is also random within cells defined by the values of the variable $p(X)$. As a result, when we have a population of units denoted by j, if the propensity score $p(Xj)$ is known, the Average Treatment Effect on the Treated (ATET) can be estimated as follows:

$$\tau \equiv E\{Y1j - Y0j|Tj = 1\} \quad (10)$$

$$= E\{E\{Y1j - Y0j|Tj = 1, p(Xj)\}\} \quad (11)$$

$$= E\{E\{Y1j|Tj = 1, p(Xj)\} - E\{Y0j|Tj = 0, p(Xj)\}|Tj = 1\} \quad (12)$$

where the outer expectation is over the distribution of $(p(Xj)|Tj = 1)$ and $Y1j$ and $Y0j$ are the potential outcomes in the two counterfactual situations of treatment and no treatment (Becker and Ichino, 2002).

Another important feature of propensity score matching method is that, after matching the units, the unmatched comparison units are discarded, and not directly used in estimating the treatment impact contributing to more accurate results of the estimates.

The propensity score method uses the propensity score, based on observable predictors, to group treated and non-treated units that have similar propensity scores. This prevents bias from poor matches, especially in cases when there are many observable characteristics. The first step in the treatment effect is to estimate the propensity score. As mentioned before, there are two standard probability models that can be applied: (1) the logit model – which is used in this study, and (2) the probit model. Those propensity scores for each observation will then be used to match treated and non-treated units by creating blocks that contain units with similar propensity scores. Most applications in the statistics literature (and therefore more researchers) have typically used the logit model (Mahasuweerachai, Whitacre, and Shideler 2010).

The next step in successfully estimating the Average Treatment Effect is avoiding bias in the estimation of the Average Treatment Effect on Treated, which could emerge as a result of an incorrect specification of the propensity score. Therefore an algorithm for estimating the propensity scores is used, followed by a test of whether the employed logit model meets a specific balancing property (Becker and Ichino, 2002). This test verifies that the treated and non-treated groups of each block have the same distribution of covariates, ensuring the correct balance of the covariates components. After getting a propensity score that satisfies the balancing property, the treated and non-treated groups must be appropriately matched. Because of the continuous nature of the propensity score variable, difficulties can occur when matching observations from the various blocks. To overcome this problem literature suggests various methods, and four of the most widely used are (1) Nearest Neighbor Matching, (2) Stratification and Interval Matching, (3) Caliper and Radius Matching, and (4) Kernel Matching.

The Nearest Neighbor Matching technique matches the treated unit with non-treated units with the closest propensity score. Sometimes these matches yield poor results because the difference between propensity scores treated and nearest non-treated units are large.

The Stratification method divides the range of variation of the propensity score into intervals (or strata). Each interval in both the treated and control groups then have the same propensity score (on average). However, one of the limitations of the Stratification method is that it discards observations in blocks when treated or control units are absent. This is why this model is applied “with replacement”, meaning that a control unit can be a best match for more than one treated unit (Becker and Ichino, 2002).The Nearest Neighbor method offers a solution to this problem, but as mentioned, some of these matches are fairly poor, because the nearest neighbor may have a very different propensity score for some treated units. Solutions for this problem can be found by implementing the Caliper and Radius Matching and Kernel Matching methods.

Caliper and Radius Matching method uses a predefined neighborhood on the maximum propensity score distance (caliper or radius) to avoid the risk of poor or bad matches. If the dimension of the caliper/radius is set to be fairly small, there is a possibility that some treated units will not be matched because the caliper/radius does not contain any control units. On the other hand, a smaller caliper/radius size yields better quality of the matches.

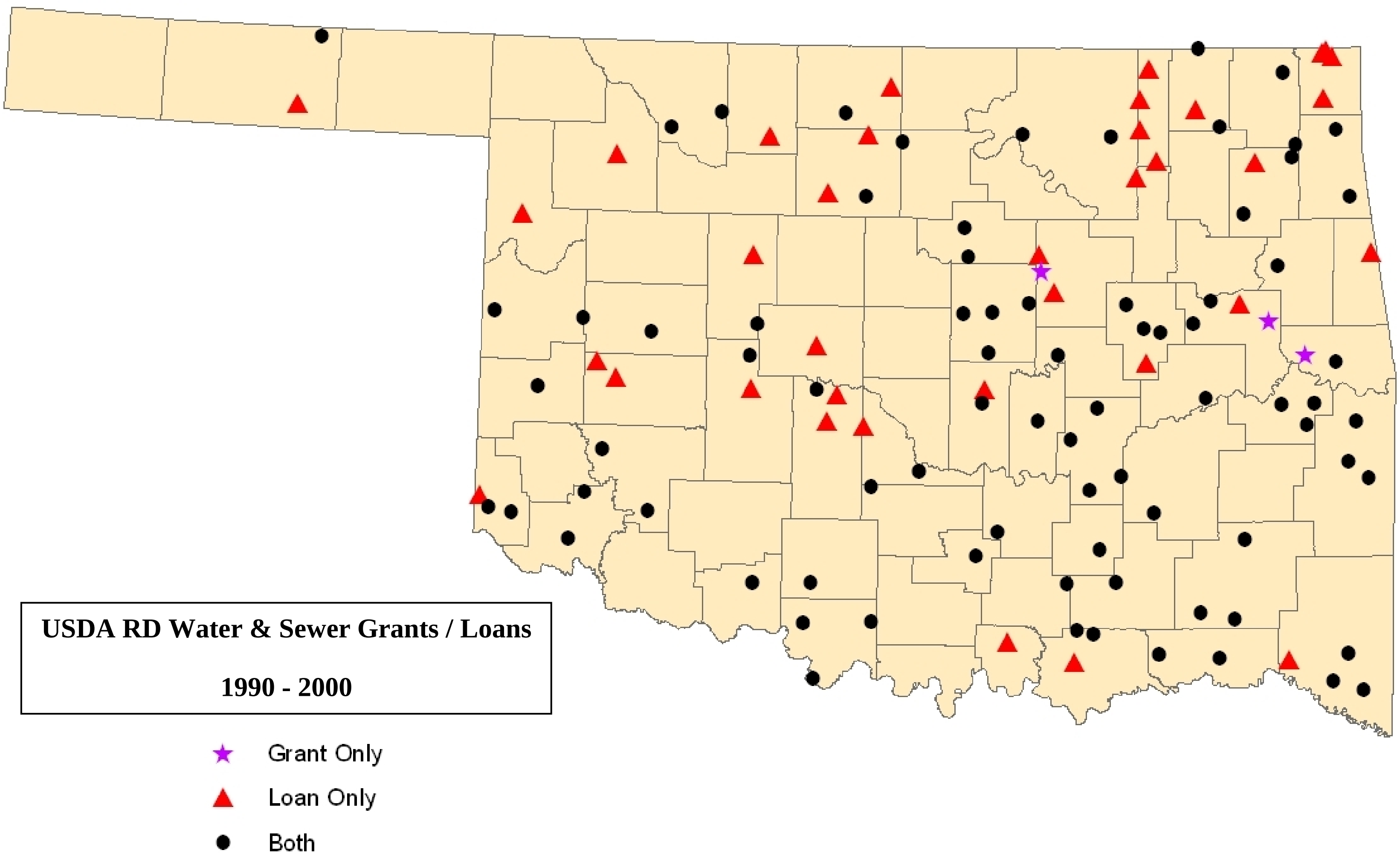
Kernel matching is usually used along with Nearest Neighbor Matching method for solving the issues of large differences between treated and non-treated units. The Kernel Matching method uses weighted averages of all cases in the control group to estimate counterfactual outcomes. The weight is calculated by the propensity score distance between a treatment case and all control cases. Then the closest control cases are given the greatest weight (Chen and Zeiser, 2008). In order to ensure the robustness of the results from the analysis in this paper, both the Nearest Neighbor Matching and Kernel matching techniques are used to estimate water and sewage investment's effect on different measures of economic growth.

3.4. Data Description

Data on the existence of water / sewer infrastructure projects in Oklahoma during the period of 1990 – 2000 was provided by the state USDA Rural Development Office. Project funds (both grants and loans, with about a 30 - 70 ratio) are limited to communities of less than 10,000 population, and communities must be denied credit through normal commercial banks to be eligible (U.S. General Accounting Office, 1995 and 1998; Copeland, 2010; USDA Rural Development website http://www.rurdev.usda.gov/UWEP_HomePage.html). Each project was manually linked to a community in Oklahoma, along with the amount of funding (broken out by grant and loan totals) and year of commitment. A total of 143 communities which received USDA water / sewer funding (and where water/sewer infrastructure projects were implemented) for the observed period are included in the study, located in a wide variety of communities across the state (Figure 1).

Data on community-level economic and socioeconomic measures comes from the U.S. Census Bureau's data series from Census 1990, Census 2000, and estimates from American Community Survey (ACS) 2005-2009. After eliminating communities that did not exist in every time period (and for which data for all variables of interest were not available on the U.S. Census Bureau database), 564 places were included in the final dataset, from which 143 received funding, and 426 did not received funding. Because the goal of rural development programming is to improve economic conditions in rural areas, measures of general economic development are used in the final dataset (as opposed to other types of private productivity measures listed in Table 1).

Figure 1. USDA Rural Development Water / Sewer Infrastructure Grants and Loans in Oklahoma, 1990 – 2000.



The data set includes the following variables, each at the city level, which are used to compute the dependent variables: (1) population; (2) median household income; (3) per-capita income; (4) percent of households with earnings; (5) percent of households with self-employment income; (6) percent of population living in poverty; (7) percent of vacant housing units; and (8) median housing value[3].

Growth rates for the economic indicator variables were created for both the short (1990 – 2000) and long (1990 – ACS) term. The mean values for these growth rates, broken into categories for cities that received / did not receive funding, are shown in Table 2.

Table 2. Summary statistics for the dependent variables: Mean cumulative growth rates in % (Treated = received funding)

Dependent variable	**Growth Rates 1990-2000**			**Growth Rates 1990-ACS2009**		
	Not treated	Treated		Not treated	Treated	
1. Population (ln)	7.1	8.7		9.9	10.4	
2. Median HH income(ln)	56.4	62.4		103.8	108.9	
3. Per-capita income (ln)	61.1	62.1		112.6	105.6	
4. % of HH with earnings	2.3	5.0	**	2.3	6.7	**
5. % of HH with self-employment income	-3.6	13.6		-17.6	-16.5	
6. % in poverty under 1.00	0.4	-15.7		6.3	-2.6	
7. % vacant housing units	-13.6	-9.1		13.9	24.9	
8. Median house value (ln)	45.8	48.1		117.2	131.9	**

NOTE: ** indicates that the means are statistically different at the 5 percent confidence level.

Data for the explanatory variables include the following socioeconomic factors: (1) racial/ethnic characteristics of the population; (2) education levels (percent of population with different education levels); (3) mean travel time to work (i.e., 15 minutes); (4) percentage of population included in the labor force; (5) households lacking

[3] Data with dollar values for median household income, per-capita income, and median house values for both short-term (1990-2000), and long-term (1990-ACS2005-09), are not adjusted for inflation.

complete plumbing facilities; (6) median year of structures built; (7) population density, (8) unemployment rate, and (9) RUCA codes[4].

Simple t-tests of the mean growth rates demonstrate that most of the economic growth measures did not statistically differ between communities that received or did not receive water infrastructure funding (Table 2). Even though numbers show that places with water infrastructure investments typically experienced greater growth for nearly all examined measures, widely fluctuating standard errors on these estimates lead to only a few variables demonstrating significantly different means. Table 2 demonstrates that the growth rate in the percentage of households with earnings is significantly higher for treated communities over both the short and long-term. Similarly, median house values increased by 131.9 percent in communities that received a water project over the long term, which is statistically higher than the 117.2 percent increase seen in communities without a project. Thus, we can say that at least some type of economic growth has occurred in communities that received this type of infrastructure funding. Furthermore, simple t-tests of the mean growth rates for both grant funding, and loans were run separately. Results of these t-tests are included in Appendix A.

The average values for the independent variables, broken into categories for cities that received / did not receive funding for the years 1990 and 2000, are shown in Table 3. Detailed description of all explanatory variables (socioeconomic factors) included in the OLS/ATE models, together with the information on the periods for which the data were obtained, is provided in Table 4.

[4]Rural Urban Commuting Area Codes, included as a proxy variable for distance to metropolitan areas.

Table 3. Summary statistics for the independent variables: Averages (Treated = received funding)

Independent variable	1990		2000	
	Not treated	Treated	Not treated	Treated
1. % Black Population	3.74	6.07	3.73	5.44
2. % Other Population	10.25	10.94	10.07	11.03
3. % Population with Bachelor Degree	6.13	5.83	8.09	7.32
4. % of Population with Mean Travel Time to Work 15min.	37.65	43.89	33.31	39.27
5. % of Population Included in the Labor Force	55.58	53.26	57.02	55.01
6. % of HH Lacking Complete Plumbing Facilities	1.86	1.45	2.72	2.22
7. Median Year Structure Built	1962	1962	1964	1963
8. Population Density	840.60	896.10	804.90	828.10
9. Unemployment Rate	5.60	6.10	3.30	3.60
10. RUCA Codes	/	/	6.37	7.04

NOTE: none of the average values are statistically significant than zero.

However, simple t-tests do not allow singling out the impact of infrastructure, and they do not lead to statements about causality. For these results, regression analysis and average treatment effects are used.

Table 4. Explanatory variables included in all OLS/ATE models

	Name of the variable	Description	For periods
1.	Racial/Ethnic Characteristics	% of Black Population; % Others	Census 1990; 2000, and ACS 2005-09
2.	Education Levels	% of Population with Bachelor Degree	Census 1990; 2000, and ACS 2005-09
3.	Mean Travel Time to Work	% of Population with less than 15 Minutes of Mean Travel Time to Work	Census 1990; 2000, and ACS 2005-09
4.	% of Population in Labor Force	City-level Information	Census 1990; 2000, and ACS 2005-09
5.	% of HH Lacking Complete Plumbing Facilities	City-level Information	Census 1990; 2000, and ACS 2005-09
6.	Median Year of Structures Built	City-level Average Age of the Houses	Census 1990; 2000, and ACS 2005-09
7	Population Density	Population on Square Mile	Census 1990; 2000, and ACS 2005-09
8.	Unemployment Rate	County-level Information	Data for 1990; 2000, and year 2007
9.	RUCA Codes	Proxy for Distance to Metro Areas	For year 2006 only

CHAPTER IV

FINDINGS

4.1 Ordinary Least Squares Regression Results

The following section presents the outcomes of this study. In order to make stronger statements on the economic impact of water-supply and sewer projects implemented this research is conducted in three steps. Evaluation techniques include the examination of the simple descriptive statistics by conducting t-tests on all outcome variables - different measures of economic growth for both short-term and long-term (as discussed in the previous section), multivariate regression and average treatment effects by incorporating a propensity score matching technique to determine causality. The results are presented in Tables 2, 5, and 7, as well as in Appendices A through F.

Following the conceptual growth model explained in section 3.2., the growth rate variables for the periods 1990-2000 and 1990-2009 are created, and their mean values recorded. The cumulative growth rates for both periods are reported in Table 2. The dependent variables are converted to natural logs as suggested by equation (1) and regressed against a host of independent variables. A total of eight different models were examined, and final model specifications (both for short and long-term) included all control and outcome variables. When incorporating only the socioeconomic factors (control variables), the insignificance of the results suggested that the models were poorly specified. The coefficient of determination was too low for most of the models, and the absence of statistical significance of parameter estimates suggested low explanatory power of the variables. Including other dependent variables as control variables yielded much better results. The results of the greatest interest in this part are related to the magnitude and significance of the funding variable, the dummy variable(I_t). Results of the OLS regression are reported in Table 5. Step three of this study, as mentioned, is assessing causality by employing the average treatment effect methods. Results of this examination are reported in Table 7.

Table 5 provides the results of the eight regression models as laid out in equation (1). Each equation includes a series of control variables as listed in section 3.4. In particular, each model not only includes the socioeconomic variables described above, but also other dependent variables included in Table 2. Thus, each equation controls for a host of other factors that might also influence growth rates in the variable being described, hopefully allowing for isolation of the impact from the water / sewer infrastructure program. Note that Table 5 only reports the coefficients / t-values associated with the infrastructure dummy variable for the sake of brevity. Full regression results are presented in Appendix D. Generally speaking, however, the coefficients associated with other variables in the analysis are consistent with previous studies using similar dependent variables – such as positive impacts of higher education or negative impacts of more people living in poverty. Table 5 suggests that most growth rates in various economic measures are *not* impacted by participation in the infrastructure projects. In particular, *no* short-term parameter estimates on the infrastructure variable are statistically significant and only 2 long-term coefficients are significant: the percentage of households with earnings, and the median household value. Interpretation of these coefficients suggests that communities that participated in infrastructure projects had 4% higher growth in the percentage of households with earnings, and 7.3% higher growth in their mean household values. Only two out of sixteen specification models uncovered statistical significance of the funding variable, both at 5 percent confidence level. Appendix D.4 provides the full specification results for households with earnings. Other variables that impact growth rates in the percentage of households with earnings are the percentage of black residents, and the percentage of residents included in the labor force. Increases in these variables result in a decrease in the growth rate of the percentage of households with earnings, a somewhat surprising result.

Table 5. OLS Results: significance of the Infrastructure funding dummy variable

Dependent Variable	**Short term (1990-2000)**			**Long term (1990-ACS2009)**		
	Coefficient	t-value	R^2	Coefficient	t-value	R^2
POP	.026	0.97	0.121	.047	1.29	0.155
MHI	.009	0.49	0.330	-.006	-0.22	0.159
PCI	-.009	-0.49	0.205	-.005	-0.23	0.132
HHE	.015	1.40	0.209	.040**	2.29	0.172
HHSEI	.048	0.88	0.143	.056	0.90	0.066
POV	-.005	-0.12	0.085	.052	0.85	0.110
VHU	-.006	-0.15	0.129	.041	0.73	0.107
MHV	.004	0.18	0.112	.073**	2.53	0.072

NOTE: ** indicates significance at the 5 percent confidence level.

Appendix D.8 provides the full results for the median house value OLS model. Besides the funding variable, only the RUCA codes have an impact on growth rates in median house value. This result is expected, because as the RUCA code increases (places become more rural), their housing values are expected to decline. However, some concern arises from rather low values of the coefficients of determination, especially for the median house value which stand at a low 7.2 percent, and not as low for households with earnings (which suggest that 17.2 percent of variation is explained with the model). When compared, the results from t-tests and regression analysis are consistent and unveil the same significance for two variables – households with earnings and median house values.

It is important to note that the coefficients included in Table 5 deal specifically with dummy variables for the implementation of any type of water / sewer program in the community. Separate regressions were run on dummies for programs funded only by loans or grants, with findings similar to those in Table 5. Results of these testing are reported in Appendices B2, and B4. Further, a host of regressions using the dollar value of the grants and loans were run (as opposed to simple dummy variables), but did not obtain any significant short or long-term impacts (Appendices B1, B3 and B5). Full OLS model results for both the short-term and long-term including the funding dummy variable are included in Appendix D.

Multivariate regression, however, does not allow making statements about causality, and further requires specific assumptions regarding distributions, heteroskedasticity, and misspecification. A battery of specification tests on the OLS assumptions revealed that there were initially some issues with several of these assumptions, including problems with heteroskedasticity (via the Cook-Weisberg test) and omitted variables (via the Ramsey RESET test). The results of the OLS specification tests are laid down in Table 6, and remedial measures for normality are included in

Appendix C[5]. Attempts to control for these issues result in the coefficients displayed in Table 5, however, they still lead to questions regarding the robustness of these results. Thus, the average treatment effect methodology is employed, in an effort to see whether it helps to confirm or refute the OLS findings.

[5] In Appendix C – First table lays down the results of remedial measures for t-tests in short-term; and Second table displays remedial measures for long-term.

Table 6. Remedial measures for OLS models (funding dummy variable)

2000-1990

Variable	R-sq	Adj. R-sq	Heteroskedasticity (Cook-Weisberg test)		Ommited Variables (ovtest)	
			chi 2	p-value	F-value	p-value
Population	0.121	0.094	60.58	0.0000	0.70	0.5503
Median HH Income	0.330	0.308	21.85	0.0000	3.56	0.0141
Per Capita Income	0.205	0.205	102.50	0.0000	6.84	0.0002
HH With Earnings	0.209	0.185	11.11	0.0009	0.74	0.5293
HH With Self-Empl. Income	0.143	0.116	5.61	0.0178	2.31	0.0754
In Poverty Under 1.00	0.085	0.056	12.86	0.0003	0.98	0.4021
Vacant Housing Units	0.129	0.101	69.69	0.0000	1.79	0.1475
Median House Value	0.112	0.085	88.1	0.0000	4.41	0.0044

2009-1990

Variable	R-sq	Adj. R-sq	Heteroskedasticity (Cook-Weisberg test)		Ommited Variables (ovtest)	
			chi 2	p-value	F-value	p-value
Population	0.1558	0.129	9.56	0.0020	0.45	0.7156
Median HH Income	0.1868	0.159	0.22	0.6415	2.05	0.1065
Per Capita Income	0.1329	0.104	73.87	0.0000	0.28	0.8428
HH With Earnings	0.1720	0.146	362.18	0.0000	5.26	0.0014
HH With Self-Empl. ncome	0.0663	0.034	7.41	0.0065	0.25	0.8643
In Poverty Under 1.00	0.1106	0.081	24.13	0.0000	0.58	0.6253
Vacant Housing Units	0.1071	0.078	56.24	0.0000	0.28	0.8372
Median House Value	0.0729	0.044	16.23	0.0001	2.59	0.0522

4.2 Average Treatment Effect Results

The ATE analysis begins by specifying a logistic model to estimate the likelihood of receiving infrastructure funding. The results of this logit model are shown for both the short and long-term in Appendix E. This model is then used to generate propensity scores (probabilities) of receiving funding for 2 groups: 1 that did receive funding, and 1 that did not. An algorithm developed by Becker and Ichino (2002) is used to ensure that the "balancing property" between the 2 groups is met. This algorithm gives an assurance that the propensity scores estimated and all observable characteristics between treated - places with funding, and not-treated – with no funding, are in fact statistically identical. Furthermore, the application of this test will uncover whether the balancing property is satisfied in the model being estimated, or whether some variables should be dropped from the model. Since all models in this study have satisfied the necessary balancing property, the average treatment effect is applied to match the treated with not-treated places for all eight dependent variables. The analysis then compares growth rates in these places using both kernel matching and the nearest neighbor matching method, for the short-term and long-term, separately.

Table 7 displays the results of the average treatment effect methodology for the eight dependent variables over the two time periods in question. The difference between treated and non-treated groups is observed using both the nearest neighbor and kernel matching techniques in each time period, typically with similar quantitative results. Positive differences indicate that the growth rate for the treated group was higher than the growth rate for the non-treated group.

Table 7. Average Treatment Effect Results of the funding dummy variable

Dependent Variable	Short term (1990-2000)				Long term (1990-ACS2009)			
	Nearest Neighbor		Kernel Matching		Nearest Neighbor		Kernel Matching	
	Diff.	T-stat	Diff.	T-stat	Diff.	T-stat	Diff.	T-stat
POP	.043	0.99	.051	1.15	.069	1.17	.075	1.26
MHI	.060	0.19	.044	0.17	-.041	-0.59	-.041	-0.60
PCI	-.055	-1.08	-.053	-1.34	-.142*	-1.89	-.099	-1.49
HHE	-.002	-0.17	.001	0.11	.011	0.59	.014	0.76
HHSEI	.068	0.54	.015	0.15	-.040	-0.43	-.034	-0.39
POV	-.083	-1.02	-.091	-1.12	-.034	-0.33	-.021	-0.22
VHU	.006	0.14	.028	-0.72	.097	1.30	.054	0.72
MHV	-.009	-0.25	-.016	-0.47	.090	1.15	.140*	1.89

NOTE: * indicates significance at the 10 percent confidence level.

Only two impacts of USDA infrastructure funding are identified using the ATE approach, and each is significant at only 10 percent confidence level. Notably, the kernel matching technique identifies a 14 percentage point difference in the growth rates of median household values for communities that obtained an infrastructure project. This impact occurs only over the long term and is somewhat consistent with the 7.3 percentage point difference identified using multivariate regression. The other impact identified using multivariate regression (an increase in the percentage of households with employment) is not verified under ATE methodology.

Interestingly, Table 7 does suggest that USDA water / sewer infrastructure projects actually caused per capita income growth to be lower over the long term. However, statistical significance was not found using the more restrictive kernel matching technique, implying that the result might be due to a few very large differences in propensity scores between the treated and non-treated groups. Further, a relationship between participation and per-capita income was never observed in the regression analysis or even t-tests, so this result is viewed as an anomaly.

Further, Average Treatment Effects methods were also used to estimate the causality for both loans and grants funding dummy variable, separately. Results of this procedure for both short-term and long-term, under nearest neighbor and kernel matching techniques are reported in Appendix F of this study. Finally, after completing all three stages in this research, there is enough confidence to say that the results from the ATE method are generally consistent with the results from OLS models. The next section draws on these similarities and summarizes the result of the analysis.

CHAPTER V

CONCLUSION

Two main findings dominate this study's effort to uncover the relationship between participation in the USDA rural development water / sewer infrastructure program and various measures of economic growth. The first is that *no* short-term (less than 10 years) impacts were documented, regardless of the econometric technique used. The second is that over the long-term (10 – 20 years), only growth rates in median household value demonstrate a positive response to infrastructure program participation using both OLS and ATE methods. Quantitatively, communities that obtain a water infrastructure project can expect their median household values to increase by between 7 and 14 percentage points higher than in an otherwise similar community without a water infrastructure project.

In particular, the ATE results allow for the claim to be made that increased growth in median house values in Oklahoma communities that received USDA infrastructure funding was mainly caused by these investments. However, the program cannot make similar claims about other community economic variables of interest, such as median household income, population, or poverty levels.

From a policy standpoint, the first finding suggests that infrastructure programs should not expect a quick turnaround on their investment. The fact that only one long-term impact was robustly documented in this study does not necessarily suggest that the USDA water infrastructure program is misguided or is spending money inappropriately. As the requirements for the program suggest, communities that apply are generally small and have limited options for improving their infrastructure. At a minimum, however, this analysis should lead policymakers to question what type of an impact they expect similar types of programs to have, and over what time frame this impact is expected to be shown. Of course, infrastructure improvements are likely to have impacts on difficult-to-quantify concepts such as resident quality of life. There are many good reasons to want to fund water and sewer infrastructure in rural communities, but making an attempt to assess whether it is having the desired impact is important to do on a regular basis – if only to discuss loosening or tightening the application requirements.

The ability to prescribe universal policy implications is tempered by the limitations of this research. First, in the choice of both outcome and control variables, this study was limited by the availability of data at the community level. The explanatory power of these chosen variables was relatively low in our regression specifications. However, other potentially influential variables such as industry composition or job growth are typically not available at the community level. Second, several other federal programs (aside from USDA) assist rural communities with water infrastructure funding. These programs include the Environmental Protection Agency's Drinking Water State Revolving Fund; the Economic Development Administration's Public Works Grants, and the Department of Housing and Urban Development's Community Development Block Grants. Copeland (2010) specifies the percentage of these funds allocated to rural areas, typically around 20 – 30%. Including these other potential sources of infrastructure funding may alter the findings of this paper. However, community-level data on where these funds were spent in Oklahoma for the time period in question was not readily available, and this task is considered as an extension to the work shown here.

The general consensus in all previous research is that public infrastructure is basic for a regions economic development (Eberts, 1994). It is a simple basic necessity for the functioning of businesses and the well-being of residents. It provides more opportunity to utilize the existing amenities, and it is an amenity itself, enabling higher life quality. Eberts points out that public and private infrastructure investments are complements, and the time sequence of which kind of capital (public or private) will be invested in infrastructure has been mixed. This analysis had added to the body of literature regarding the return to publicly provided infrastructure by focusing on one specific program (USDA water infrastructure in Oklahoma) and finding only long-term (15+ years) impacts.

There is no way of knowing what type of growth the communities that did receive infrastructure funding would have had without it. In many cases, the USDA was the "lender of last resort" for these cities, and without them their water infrastructure situation would have continued to deteriorate. Thus, the provision of water infrastructure is a "necessary but not sufficient" condition for economic growth, and this research has shown that in some cases it not only helps communities keep up but also sometimes outgrow communities without funding. Furthermore, many of these communities which received funding are losing population, and therefore cannot meet the requirements for commercial loans (decline in the tax base results in less income for town's budgets).

One additional consideration is that households in areas where safe drinking water and wastewater standards are not met face the possibility of being relocated. Relocation costs in these instances are typically provided by the state or federal government. In these cases, the provision of water / sewer infrastructure can be seen as a way of avoiding the significant costs associated with relocation. The water / sewer investments may not turn things around, but can slow down the process of population decline.

Generally this study has documented that there is at least one long-term positive economic impact of the USDA rural development water and sewer infrastructure program in Oklahoma. Documenting similar impacts for infrastructure programs in other states and across regions will be important as the fight for federal and state funds continues. Notably, statements about causality (as this analysis has attempted to make) can build strong cases for continued or increased funding.

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APPENDICES

APPENDIX A. Summary Statistics

Table A1. Summary statistics: Grants - Mean cumulative growth rates in % (Treated = received funding)

Dependent variable	**Growth rates 1990-2000**		**Growth rates 1990-ACS2009**	
	Not treated	Treated	Not treated	Treated
Population	7.2	7.3	10.1	6.5
Median household income	56.5**	64.4**	103.9	109.8
Per-capita income	61.2	67.3	112.9	108.8
Households with earnings	2.4**	5.1**	2.3**	7.3**
HH with self-employment income	-3.8**	22.0**	-17.5	-11.6
In poverty under 1,00	0.2*	-20.6*	6.1	-8.9
Vacant housing units	-13.6***	-2.4***	13.7***	33.9***
Median house value	45.9	45.9	117.4**	131.1**

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table A2. Summary statistics: Loans – Mean cumulative growth rates in % (Treated = received funding)

Dependent variable	**Growth rates 1990-2000**		**Growth rates 1990-ACS2009**	
	Not treated	Treated	Not treated	Treated
Population	7.1	8.5	9.9	10.9
Median household income	56.4**	62.9**	103.8	107.6
Per-capita income	61.1	58.7	112.6	105.6
Households with earnings	2.3**	5.0**	2.3**	6.0**
HH with self-employment income	-3.8	6.3	-17.6	-14.8
In poverty under 1,00	0.4	-15.2	6.3	-2.3
Vacant housing units	-13.6	-8.5	13.9	25.1
Median house value	45.8	48.8	117.2**	130.5**

NOTE: ** indicates significance at the 5 percent confidence level.

APPENDIX B. Summary OLS Results for Grants/Loans

Table B1. OLS Results: Significance of the continuous Infrastructure funding dummy variable

Dependent	Short term (1990-2000)			Long term (1990-ACS2009)		
Variable	Coefficient	t-value	R^2	Coefficient	t-value	R^2
POP	.0007	0.96	0.120	.001	1.31	0.155
MHI	.0001	-0.19	0.329	-.002*	-1.74	0.191
PCI	-.001	-0.30	0.206	-.0003	-0.37	0.132
HHE	.0002	1.67	0.207	.0003	0.35	0.166
HHSEI	.0004	-0.24	0.142	.0005	0.29	0.065
POV	.0001	0.10	0.085	.001	0.64	0.110
VHU	.001	0.76	0.129	.003*	1.99	0.109
MHV	.0005	-0.57	0.113	.0007	0.55	0.063

NOTE: *, indicates significance at the 10 percent confidence level.

Table B2. OLS Results: Significance of the Grants infrastructure dummy variable

Dependent	Short term (1990-2000)			Long term (1990-ACS2009)		
Variable	Coefficient	t-value	R^2	Coefficient	t-value	R^2
POP	.015	0.47	0.121	.025	0.62	0.159
MHI	.009	-0.44	0.346	-.033	-0.96	0.204
PCI	.001	0.05	0.218	-.032	-1.16	0.307
HHE	.012	1.00	0.213	.040*	1.97	0.184
HHSEI	.056	0.85	0.147	.068	0.89	0.068
POV	-.032	-0.65	0.086	.030	0.44	0.109
VHU	.071	1.54	0.134	.154**	2.64	0.119
MHV	.022	-0.84	0.122	.062*	1.91	0.072

NOTE: *, ** indicates significance at the 10 and 5 percent confidence level, respectively.

Table B3. OLS Results: Significance of the Grants continuous infrastructure variable

Dependent	Short term (1990-2000)			Long term (1990-ACS2009)		
Variable	Coefficient	t-value	R^2	Coefficient	t-value	R^2
POP	.0001	0.08	0.121	.001	0.54	0.159
MHI	.0003	0.85	0.346	.0009	0.31	0.138
PCI	-.0007	-0.46	0.218	.0009	0.46	0.132
HHE	.001	0.87	0.238	.001	0.63	0.180
HHSEI	.004	0.50	0.146	.001	0.37	0.066
POV	-.0009	-0.24	0.086	.0008	0.16	0.109
VHU	-.007*	1.72	0.135	.012***	3.48	0.117
MHV	.002	-1.02	0.122	.001	0.43	0.067

NOTE: *, *** indicates significance at the 10 and 1 percent confidence level, respectively.

Table B4. OLS Results: Significance of the Loans infrastructure dummy variable

Dependent Variable	Short term (1990-2000)			Long term (1990-ACS2009)		
	Coefficient	t-value	R^2	Coefficient	t-value	R^2
POP	.025	0.93	0.120	.048	1.32	0.154
MHI	.016	1.18	0.334	-.010	-0.34	0.185
PCI	-.013	-0.71	0.205	-.005	-0.20	0.137
HHE	.017	1.49	0.207	.034**	2.04	0.169
HHSEI	.033	0.62	0.130	.053	0.86	0.066
POV	-.002	-0.06	0.086	.059	0.96	0.111
VHU	.000	0.00	0.133	.038	0.66	0.107
MHV	.009	0.45	0.124	.070**	2.40	0.066

NOTE: ** indicates significance at the 5 percent confidence level.

Table B5. OLS Results: Significance of the Loans continuous infrastructure variable

Dependent Variable	Short term (1990-2000)			Long term (1990-ACS2009)		
	Coefficient	t-value	R^2	Coefficient	t-value	R^2
POP	.001*	1.66	0.120	.003	1.56	0.154
MHI	-.010	-0.11	0.333	-.003	-1.56	0.188
PCI	-.002*	-1.72	0.207	-.001	-0.88	0.137
HHE	.0000	0.06	0.204	.0002	0.18	0.165
HHSEI	-.001	-0.64	0.129	.0000	0.01	0.064
POV	-.000	0.34	0.086	.003	0.89	0.110
VHU	-.000	-0.31	0.133	.002	0.74	0.107
MHV	.000	-0.10	0.124	.001	0.59	0.058

NOTE: * indicates significance at the 10 percent confidence level.

APPENDIX C. Remedial measures for t-tests

	2000-1990						
Variable	ttest		transformation			ttest after transf.	
	t-value	p-value	formula	chi^2	p-value	t-value	p-value
Population	-0.4552	0.6492	/	/	/	/	/
Median HH Income	-1.3862	0.1662	1/(sqrt)	69.31	0.0000	2.3743	0.0118
Per Capita Income	-0.2013	0.8405	1/(sqrt)	52.61	0.0000	0.5247	0.6000
HH With Earnings	-1.9727	0.0490	log	56.38	0.0000	-2.0713	0.0388
HH With Self-Empl. Income	-1.7542	0.0800	/	/	/	/	/
In Poverty Under 1.00	1.4933	0.1359	/	/	/	/	/
Vacant Housing Units	-1.0958	0.2736	sqrt	41.38	0.0000	-1.4171	0.1570
Median House Value	-0.7222	0.4705	sqrt	33.09	0.0000	-0.8842	0.3770

	2009-1990						
Variable	ttest		transformation			ttest after transf.	
	t-value	p-value	formula	chi^2	p-value	t-value	p-value
Population	-0.1018	0.9190	log	73.47	0.0000	-0.4248	0.6712
Median HH Income	-0.7721	0.4404	log	39.19	0.0000	-1.1778	0.2394
Per Capita Income	0.9499	0.3426	log	65.25	0.0000	0.748	0.4548
HH With Earnings	-2.4781	0.0135	identity	/	/	/	/
HH With Self-Empl. Income	-0.1372	0.8909	sqrt	61.76	0.0000	0.1675	0.8670
In Poverty Under 1.00	0.7834	0.4338	/	/	/	/	/
Vacant Housing Units	-1.5324	0.1260	sqrt	38.57	0.0000	-1.5516	0.1213
Median House Value	-2.1529	0.0317	log	16.41	0.0000	-2.1529	0.0317

APPENDIX D. Full Regression Results - ***Table D1. OLS regression of Population (2009 – 1990)***

Linear regression						**Number of obs =**	**564**
						F(17, 546) =	**3.68**
						Prob > F =	**0.0000**
						R-squared =	**0.1558**
						Root MSE =	**.41752**
lnpopulation	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]	
black1990	-.0045464**	0.0017686	-2.57	0.01	-0.0080204	-0.0010723	
otherra~1990	-0.00278	0.0020263	-1.37	0.171	-0.0067602	0.0012003	
travel15m~90	-.0008625	0.0012202	-0.71	0.48	-0.0032594	0.0015344	
laborfo~1990	-.0018947	0.0038256	-0.5	0.621	-0.0094095	0.0056201	
lacking~1990	0.0003358	0.0071582	0.05	0.963	-0.0137252	0.0143967	
medyear~1990	0.0077456**	0.0024553	3.15	0.002	0.0029226	0.0125685	
popdens~1990	5.36E-06	0.0000311	0.17	0.863	-0.0000558	0.0000665	
unemplo~1990	-.0062243	0.0108097	-0.58	0.565	-0.0274581	0.0150094	
bachelor1990	-.0057759	0.0067642	-0.85	0.394	-0.019063	0.0075111	
lnpercapit~3	0.1425329	0.1488007	0.96	0.339	-0.1497592	0.4348249	
hhwithe~1990	-.0031429	0.0039725	-0.79	0.429	-0.010946	0.0046603	
hhwiths~1990	-0.005536	0.0034861	-1.59	0.113	-0.0123838	0.0013117	
inpo~1001990	0.0012735	0.0030521	0.42	0.677	-0.0047218	0.0072688	
vacanth~1990	0.005601	0.0032705	1.71	0.087	-0.0008232	0.0120252	
lnmedianho~3	0.2895877**	0.0989536	2.93	0.004	0.0952113	0.4839641	
rucacod~2006	0.0016745	0.0076327	0.22	0.826	-0.0133186	0.0166675	
fundingrec~o	0.0470327	0.0365552	1.29	0.199	-0.0247733	0.1188386	
_cons	-19.03997	4.884081	-3.9	0	-28.63386	-9.446079	

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively

Table D2. OLS regression model of Median household's income (2009 – 1990)

Source	SS	df	MS		
Model	10.9131368	18	.606285379	**Number of obs =**	**564**
Residual	47.5169676	545	.087187097	**Prob > F =**	**0.0000**
				R-squared =	**0.1868**
				Adj R-squared =	**0.1599**
Total	58.4301045	563	.103783489	**Root MSE =**	**.29527**

lnmedianhh~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.003147**	0.0010886	-2.89	0.004	-0.0052854	-0.0010086
otherra~1990	-0.00333**	0.0014311	-2.33	0.02	-0.0061411	-0.0005189
travel15m~90	0.0017033*	0.000878	1.94	0.053	-0.0000213	0.0034279
laborfo~1990	0.0015992	0.0020383	0.78	0.433	-0.0024046	0.005603
lacking~1990	0.0011781	0.0045214	0.26	0.795	-0.0077033	0.0100595
medyear~1990	-0.0027059*	0.0016195	-1.67	0.095	-0.005887	0.0004753
popdens~1990	-0.0000294	0.0000237	-1.24	0.215	-0.0000758	0.0000171
unemplo~1990	0.0004845	0.0077502	0.06	0.95	-0.0147394	0.0157084
bachelor1990	0.0150837***	0.0040147	3.76	0	0.0071974	0.0229699
lnpopulati~3	-0.016676	0.0126906	-1.31	0.189	-0.0416046	0.0082525
lnpercapit~3	-0.4637775***	0.0837068	-5.54	0	-0.628205	-0.2993499
hhwithe~1990	-0.0057289**	0.00189	-3.03	0.003	-0.0094416	-0.0020163
hhwiths~1990	0.0030756*	0.0016539	1.86	0.063	-0.0001732	0.0063244
inpo~1001990	0.0040952**	0.0016292	2.51	0.012	0.0008949	0.0072956
vacanth~1990	-0.0018658	0.0014593	-1.28	0.202	-0.0047324	0.0010007
lnmedianho~3	0.076335	0.0525402	1.45	0.147	-0.0268711	0.1795411
rucacod~2006	-0.0054955	0.0047957	-1.15	0.252	-0.0149158	0.0039248
fundingrec~o	-0.0066225	0.030159	-0.22	0.826	-0.0658646	0.0526196
_cons	9.665777	3.146787	3.07	0.002	3.48446	15.84709

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively

Table D3. OLS regression for Per-capita Income (2009-1990)

Linear regression — **Number of obs = 564**

F(18, 545) = 3.38
Prob > F = 0.0000
R-squared = 0.1329
Root MSE = .27475

lnpercapit~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0005076	0.001448	-0.35	0.726	-0.0033519	0.0023367
otherra~1990	-0.0024688	0.0016969	-1.45	0.146	-0.0058021	0.0008646
travel15m~90	-0.0011477	0.0010564	-1.09	0.278	-0.0032228	0.0009274
laborfo~1990	0.0019107	0.0030027	0.64	0.525	-0.0039877	0.0078091
lacking~1990	-0.002254	0.0058601	-0.38	0.701	-0.0137651	0.0092571
medyear~1990	-0.0027803	0.0018484	-1.5	0.133	-0.0064113	0.0008506
popdens~1990	-0.0000321*	0.0000185	-1.73	0.083	-0.0000686	4.26E-06
unemplo~1990	0.0040457	0.0071675	0.56	0.573	-0.0100336	0.0181249
bachelor1990	-0.0002822	0.0038823	-0.07	0.942	-0.0079084	0.007344
lnpopulati~3	-0.0224315	0.0139142	-1.61	0.108	-0.0497635	0.0049005
lnmedianhh~3	-0.1050751	0.1123982	-0.93	0.35	-0.3258618	0.1157117
hhwithe~1990	0.0036036	0.002612	1.38	0.168	-0.0015273	0.0087345
hhwiths~1990	0.0021072	0.0018358	1.15	0.252	-0.0014989	0.0057133
inpo~1001990	0.0061649**	0.0024328	2.53	0.012	0.0013862	0.0109436
vacanth~1990	0.0004136	0.0018416	0.22	0.822	-0.0032038	0.0040311
lnmedianho~3	0.0662631	0.0605836	1.09	0.275	-0.0527428	0.185269
rucacod~2006	-0.0013758	0.005251	-0.26	0.793	-0.0116905	0.0089388
fundingrec~o	-0.0057164	0.0251598	-0.23	0.82	-0.0551386	0.0437057
_cons	6.20008	3.634005	1.71	0.089	-0.9382908	13.33845

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D4. OLS Regression for Households with Earnings (2009-1990)

Linear regression		
	Number of obs =	**564**
	F(17, 546) =	**3.95**
	Prob > F =	**0.0000**
	R-squared =	**0.1720**
	Root MSE =	**.19807**

lnhousehol~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0044505***	0.0013729	-3.24	0.001	-0.0071473	-0.0017536
otherra~1990	0.0007662	0.0009757	0.79	0.433	-0.0011504	0.0026828
travel15m~90	0.0001434	0.0009698	0.15	0.883	-0.0017616	0.0020483
laborfo~1990	-0.0053292***	0.00113	-4.72	0	-0.0075488	-0.0031095
lacking~1990	0.0049571	0.0049782	1	0.32	-0.0048216	0.0147358
medyear~1990	-0.0023693	0.001722	-1.38	0.169	-0.0057518	0.0010132
popdens~1990	0.0000106	0.0000105	1.01	0.314	-0.00001	0.0000312
unemplo~1990	0.0006922	0.0060786	0.11	0.909	-0.0112481	0.0126325
bachelor1990	0.0019452	0.0027248	0.71	0.476	-0.0034072	0.0072975
lnpercapit~3	-0.0920881	0.0742431	-1.24	0.215	-0.2379253	0.053749
lnpopulati~3	0.015173	0.0114061	1.33	0.184	-0.0072321	0.0375781
hhwiths~1990	-0.0010616	0.001788	-0.59	0.553	-0.0045738	0.0024506
inpo~1001990	-0.0019836	0.0015534	-1.28	0.202	-0.0050348	0.0010677
vacanth~1990	-0.0017366	0.0018875	-0.92	0.358	-0.0054442	0.001971
lnmedianho~3	-0.0102844	0.0369488	-0.28	0.781	-0.0828636	0.0622949
rucacod~2006	-0.0064262	0.0043754	-1.47	0.142	-0.0150209	0.0021685
fundingrec~o	0.0406011**	0.0177626	2.29	0.023	0.0057097	0.0754925
_cons	5.895209	3.539591	1.67	0.096	-1.057675	12.84809

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D5. OLS Regression for Households with self-employment income (2009-1990)

Linear regression						**Number of obs =**	**509**
						F(17, 491) =	**2.29**
						Prob > F =	**0.0024**
						R-squared =	**0.0663**
						Root MSE =	**.60864**
lnhhwithse~e	|	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	|	0.0002887	0.0033584	0.09	0.932	-0.0063099	0.0068872
otherra~1990	|	0.0003732	0.003696	0.1	0.92	-0.0068886	0.0076351
travel15m~90	|	-0.0040662**	0.0019618	-2.07	0.039	-0.0079208	-0.0002116
laborfo~1990	|	-0.004965	0.0059368	-0.84	0.403	-0.0166297	0.0066997
lacking~1990	|	-0.0006186	0.014628	-0.04	0.966	-0.0293598	0.0281226
medyear~1990	|	0.0048008	0.0041733	1.15	0.251	-0.0033989	0.0130006
popdens~1990	|	-0.0000425	0.0000417	-1.02	0.309	-0.0001245	0.0000395
unemplo~1990	|	-0.0187836	0.0182318	-1.03	0.303	-0.0546057	0.0170384
bachelor1990	|	0.0072297	0.0094309	0.77	0.444	-0.0113002	0.0257596
lnpercapit~3	|	-0.2176236	0.2191391	-0.99	0.321	-0.6481898	0.2129425
hhwithe~1990	|	-0.0092256	0.0053016	-1.74	0.082	-0.0196422	0.0011911
lnpopulati~3	|	-0.0092106	0.0246225	-0.37	0.709	-0.0575891	0.0391679
inpo~1001990	|	-0.0074248	0.0048602	-1.53	0.127	-0.0169742	0.0021246
vacanth~1990	|	-0.0058176	0.0038459	-1.51	0.131	-0.0133741	0.0017389
lnmedianho~3	|	-0.0927435	0.1468799	-0.63	0.528	-0.3813341	0.1958472
rucacod~2006	|	-0.0093149	0.0109558	-0.85	0.396	-0.0308409	0.0122111
fundingrec~o	|	0.0560644	0.0622505	0.9	0.368	-0.0662458	0.1783746
_cons	|	-5.239329	8.185489	-0.64	0.522	-21.32224	10.84358

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D6. OLS Regression for In Poverty Under 1.00 (2009-1990)

Linear regression							
						Number of obs =	**542**
						F(17, 524) =	**3.45**
						Prob > F =	**0.0000**
						R-squared =	**0.1106**
						Root MSE =	**.68637**
lninpove~100	|	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	|	0.0016381	0.0026913	0.61	0.543	-0.0036489	0.0069251
otherra~1990	|	0.0016008	0.0038501	0.42	0.678	-0.0059627	0.0091642
travel15m~90	|	-0.0002522	0.0025565	-0.1	0.921	-0.0052744	0.0047699
laborfo~1990	|	-0.0156538**	0.0067639	-2.31	0.021	-0.0289415	-0.0023661
lacking~1990	|	0.0031007	0.013079	0.24	0.813	-0.0225931	0.0287945
medyear~1990	|	0.0108474**	0.0046214	2.35	0.019	0.0017687	0.019926
popdens~1990	|	0.0000397	0.0000556	0.71	0.475	-0.0000695	0.0001489
unemplo~1990	|	-0.0418186**	0.0175911	-2.38	0.018	-0.0763764	-0.0072608
bachelor1990	|	-0.0008798	0.0124707	-0.07	0.944	-0.0253784	0.0236189
lnpercapit~3	|	0.7533786***	0.2081089	3.62	0	0.3445484	1.162209
hhwithe~1990	|	0.0070731	0.0052178	1.36	0.176	-0.0031772	0.0173234
hhwiths~1990	|	-0.0035916	0.005868	-0.61	0.541	-0.0151193	0.007936
lnpopulati~3	|	0.0490498	0.0341173	1.44	0.151	-0.0179737	0.1160733
vacanth~1990	|	0.000331	0.004365	0.08	0.94	-0.008244	0.0089061
lnmedianho~3	|	-0.1600565	0.1418747	-1.13	0.26	-0.4387695	0.1186565
rucacod~2006	|	-0.0095404	0.0117884	-0.81	0.419	-0.0326988	0.013618
fundingrec~o	|	0.0520213	0.0610134	0.85	0.394	-0.0678395	0.1718822
_cons	|	-26.33845	9.053542	-2.91	0.004	-44.12415	-8.552751

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D7. OLS Regression for Vacant Housing Units (2009-1990)

Linear regression					**Number of obs =**	**544**
					F(17, 526) =	**3.73**
					Prob > F =	**0.0000**
					R-squared =	**0.1071**
					Root MSE =	**.57711**
lnvacantho~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	0.0028384	0.0023348	1.22	0.225	-0.0017483	0.0074251
otherra~1990	0.0056372*	0.0029936	1.88	0.06	-0.0002437	0.0115182
travel15m~90	0.0004986	0.0016335	0.31	0.76	-0.0027105	0.0037076
laborfo~1990	0.005108	0.0045188	1.13	0.259	-0.003769	0.013985
lacking~1990	-0.0059773	0.0105076	-0.57	0.57	-0.0266193	0.0146648
medyear~1990	-0.0051025	0.0040986	-1.24	0.214	-0.0131541	0.0029491
popdens~1990	-7.49E-06	0.0000422	-0.18	0.859	-0.0000904	0.0000754
unemplo~1990	0.0197492	0.0159727	1.24	0.217	-0.0116289	0.0511274
bachelor1990	0.0010548	0.0092761	0.11	0.91	-0.0171679	0.0192775
lnpercapit~3	-0.0246388	0.1975676	-0.12	0.901	-0.4127573	0.3634797
hhwithe~1990	-0.0116143**	0.0050144	-2.32	0.021	-0.021465	-0.0017636
hhwiths~1990	0.0061174	0.0042723	1.43	0.153	-0.0022754	0.0145102
inpo~1001990	-0.0031612	0.0038838	-0.81	0.416	-0.0107908	0.0044685
lnpopulati~3	0.063941**	0.0273304	2.34	0.02	0.0102508	0.1176312
lnmedianho~3	-0.3412359**	0.1369674	-2.49	0.013	-0.6103062	-0.0721656
rucacod~2006	-0.0014828	0.0109686	-0.14	0.893	-0.0230304	0.0200647
fundingrec~o	0.0419606	0.0575214	0.73	0.466	-0.0710393	0.1549605
_cons	13.64278	8.013157	1.7	0.089	-2.098937	29.38451

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D8. OLS Regression for Median House Value (2009-1990)

Linear regression					**Number of obs =**	**564**
					F(17, 546) =	**2.80**
					Prob > F =	**0.0002**
					R-squared =	**0.0729**
					Root MSE =	**.30054**

		Robust				
lnmedianho~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0002731	0.001335	-0.2	0.838	-0.002895	0.0023492
otherra~1990	0.0006361	0.0015319	0.42	0.678	-0.002373	0.0036452
travel15m~90	-0.0015455	0.0010277	-1.5	0.133	-0.003564	0.0004732
laborfo~1990	-0.0035747	0.0024666	-1.45	0.148	-0.008419	0.0012704
lacking~1990	0.0038392	0.0067794	0.57	0.571	-0.009477	0.0171562
medyear~1990	-0.0012317	0.0021878	-0.56	0.574	-0.005529	0.0030658
popdens~1990	-0.0000283	0.0000197	-1.43	0.153	-0.000067	0.0000105
unemplo~1990	-0.0027168	0.0082207	-0.33	0.741	-0.018865	0.0134313
bachelor1990	-0.0006227	0.0048036	-0.13	0.897	-0.010058	0.008813
lnpercapit~3	0.0177414	0.0912234	0.19	0.846	-0.161450	0.1969331
hhwithe~1990	-0.0007322	0.0025403	-0.29	0.773	-0.005722	0.0042577
hhwiths~1990	-0.0012815	0.0024108	-0.53	0.595	-0.006017	0.0034541
inpo~1001990	0.001904	0.0021696	0.88	0.381	-0.002357	0.0061658
vacanth~1990	0.0008637	0.0019834	0.44	0.663	-0.003032	0.0047598
lnpopulati~3	0.0000515	0.0121784	0	0.997	-0.023870	0.0239737
rucacod~2006	-0.0092223*	0.0055675	-1.66	0.098	-0.020158	0.001714
fundingrec~o	0.0738488**	0.0291547	2.53	0.012	0.0165797	0.1311179
_cons	3.346873	4.384215	0.76	0.446	-5.265121	11.95887

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D9. OLS Regression for Population (2000-1990)

Linear regression						**Number of obs =**	**564**
						F(17, 546) =	**3.32**
						Prob > F =	**0.0000**
						R-squared =	**0.1215**
						Root MSE =	**.27647**

lnpopulation	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0008152	0.0012714	-0.64	0.522	-0.0033127	0.0016822
otherra~1990	0.0003962	0.0011746	0.34	0.736	-0.0019111	0.0027034
travel15m~90	-0.0003723	0.0007626	-0.49	0.626	-0.0018704	0.0011257
laborfo~1990	-0.00011	0.0023168	-0.05	0.962	-0.0046609	0.0044408
lacking~1990	0.0027385	0.0043714	0.63	0.531	-0.0058483	0.0113253
medyear~1990	0.0035349**	0.0014847	2.38	0.018	0.0006184	0.0064514
popdens~1990	-0.0000121	0.0000223	-0.54	0.587	-0.000056	0.0000318
unemplo~1990	-0.0007359	0.0065148	-0.11	0.91	-0.013533	0.0120612
bachelor1990	-0.0041371	0.0042929	-0.96	0.336	-0.0125698	0.0042956
lnpercapit~1	0.0930208	0.0822605	1.13	0.259	-0.0685649	0.2546066
hhwithe~1990	-0.0020543	0.0020846	-0.99	0.325	-0.006149	0.0020404
hhwiths~1990	-0.002441	0.0017566	-1.39	0.165	-0.0058914	0.0010095
inpo~1001990	0.0016348	0.0017618	0.93	0.354	-0.0018261	0.0050956
vacanth~1990	0.0071217***	0.0017521	4.06	0	0.00368	0.0105634
lnmedianho~1	0.1299794**	0.0551176	2.36	0.019	0.0217109	0.2382479
rucacod~2006	-0.006479	0.0043298	-1.5	0.135	-0.0149841	0.0020261
fundingrec~o	0.0260068	0.0267721	0.97	0.332	-0.0265821	0.0785956
_cons	-8.965805	3.020236	-2.97	0.003	-14.89851	-3.0331

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D10. OLS Regression for Median Households Income (2000-1990)

Linear regression					**Number of obs =**	**564**
					F(18, 545) =	**11.40**
					Prob > F =	**0.0000**
					R-squared =	**0.3302**
					Root MSE =	**.19632**
lnmedianhh~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0025258**	0.0009163	-2.76	0.006	-0.0043257	-0.0007259
otherra~1990	-0.0019922**	0.0009524	-2.09	0.037	-0.003863	-0.0001214
travel15m~90	0.0016642**	0.0007297	2.28	0.023	0.0002309	0.0030975
laborfo~1990	0.0046308**	0.0018244	2.54	0.011	0.0010471	0.0082145
lacking~1990	-0.0016869	0.0045668	-0.37	0.712	-0.0106576	0.0072837
medyear~1990	-0.0006396	0.0013469	-0.47	0.635	-0.0032854	0.0020061
popdens~1990	-0.0000144	0.0000136	-1.06	0.289	-0.000041	0.0000122
unemplo~1990	-0.0095629*	0.0049964	-1.91	0.056	-0.0193775	0.0002517
bachelor1990	0.0048974*	0.0029533	1.66	0.098	-0.0009039	0.0106987
lnpopulati~1	-0.0150669*	0.008211	-1.83	0.067	-0.031196	0.0010622
lnpercapit~1	-0.144901**	0.0651018	-2.23	0.026	-0.2727822	-0.0170198
hhwithe~1990	-0.0081439***	0.0015184	-5.36	0	-0.0111264	-0.0051613
hhwiths~1990	0.0022512	0.001605	1.4	0.161	-0.0009014	0.0054039
inpo~1001990	0.0083668***	0.0016857	4.96	0	0.0050555	0.0116781
vacanth~1990	0.0009013	0.0011555	0.78	0.436	-0.0013685	0.0031711
lnmedianho~1	0.0253156	0.0415058	0.61	0.542	-0.0562153	0.1068465
rucacod~2006	-0.009395**	0.0033533	-2.8	0.005	-0.015982	-0.002808
fundingrec~o	0.0092571	0.0187616	0.49	0.622	-0.0275968	0.0461109
_cons	2.984295	2.575068	1.16	0.247	-2.073978	8.042567

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D11. OLS Regression for Per-capita Income (2000-1990)

Linear regression					**Number of obs**	**= 564**
					F(18, 545)	**= 3.79**
					Prob > F	**= 0.0000**
					R-squared	**= 0.2050**
					Root MSE	**= .21107**
lnpercapit~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	0.0019097	0.001651	1.16	0.248	-0.0013333	0.0051528
otherra~1990	-0.0017285	0.0011188	-1.54	0.123	-0.0039261	0.0004691
travel15m~90	-0.0015317**	0.0007527	-2.03	0.042	-0.0030102	-0.0000531
laborfo~1990	-0.0021828	0.0022069	-0.99	0.323	-0.0065179	0.0021522
lacking~1990	-0.0117224**	0.0049479	-2.37	0.018	-0.0214417	-0.002003
medyear~1990	-0.0009025	0.00146	-0.62	0.537	-0.0037703	0.0019654
popdens~1990	-8.83E-06	0.0000137	-0.64	0.52	-0.0000358	0.0000181
unemplo~1990	-0.021168***	0.0055685	-3.8	0	-0.0321071	-0.0102306
bachelor1990	0.0006975	0.002836	0.25	0.806	-0.0048734	0.0062683
lnpopulati~1	-0.0015286	0.0080759	-0.19	0.85	-0.0173924	0.0143351
lnmedianhh~1	-0.1536644*	0.0792871	-1.94	0.053	-0.3094102	0.0020814
hhwithe~1990	0.0019769	0.0020943	0.94	0.346	-0.002137	0.0060908
hhwiths~1990	0.0015558	0.0015199	1.02	0.306	-0.0014298	0.0045415
inpo~1001990	0.0064052	0.0021373	3	0.003	0.0022068	0.0106035
vacanth~1990	-0.0016075	0.0012735	-1.26	0.207	-0.004109	0.000894
lnmedianho~1	0.0696626	0.0425546	1.64	0.102	-0.0139286	0.1532537
rucacod~2006	0.0040388	0.0039242	1.03	0.304	-0.0036697	0.0117473
fundingrec~o	-0.0096867	0.019939	-0.49	0.627	-0.0488533	0.0294799
_cons	3.043461	2.796541	1.09	0.277	-2.449859	8.536781

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D12. OLS Regression for Households with Earnings (2000-1990)

Linear regression — **Number of obs = 564**

F(17, 546) = 5.60
Prob > F = 0.0000
R-squared = 0.2097
Root MSE = .11853

lnhousehol~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0012795	0.0008207	-1.56	0.12	-0.0028917	0.0003327
otherra~1990	-0.0008525	0.0006679	-1.28	0.202	-0.0021644	0.0004595
travel15m~90	-0.0008651**	0.0004078	-2.12	0.034	-0.0016661	-0.0000641
laborfo~1990	-0.0058589***	0.0008827	-6.64	0	-0.0075928	-0.004125
lacking~1990	0.0003318	0.0025404	0.13	0.896	-0.0046584	0.0053219
medyear~1990	-0.0007427	0.000884	-0.84	0.401	-0.0024792	0.0009938
popdens~1990	2.49E-06	7.28E-06	0.34	0.732	-0.0000118	0.0000168
unemplo~1990	0.0011997	0.0030759	0.39	0.697	-0.0048424	0.0072418
bachelor1990	0.0007622	0.0018833	0.4	0.686	-0.0029372	0.0044615
lnpercapit~1	0.0234783	0.0469352	0.5	0.617	-0.0687173	0.1156739
lnpopulati~1	0.0061629	0.0049867	1.24	0.217	-0.0036327	0.0159584
hhwiths~1990	-0.0008001	0.0010447	-0.77	0.444	-0.0028522	0.0012519
inpo~1001990	0.0017611*	0.0009671	1.82	0.069	-0.0001387	0.0036609
vacanth~1990	-0.0004412	0.0008284	-0.53	0.594	-0.0020684	0.0011859
lnmedianho~1	0.0192843	0.0260275	0.74	0.459	-0.031842	0.0704106
rucacod~2006	-0.0011558	0.0020972	-0.55	0.582	-0.0052754	0.0029637
fundingrec~o	0.0158607	0.0113545	1.4	0.163	-0.0064432	0.0381646
_cons	1.369761	1.791624	0.76	0.445	-2.149559	4.889081

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D13. OLS Regression for Households with self-employment income (2000-1990)

Linear regression					**Number of obs =**	**546**
					F(17, 528) =	**4.64**
					Prob > F =	**0.0000**
					R-squared =	**0.1438**
					Root MSE =	**.5339**
lnhhwithse~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	-0.0022304	0.0042782	-0.52	0.602	-0.0106348	0.0061741
otherra~1990	-0.0084553**	0.0030462	-2.78	0.006	-0.0144395	-0.0024711
travel15m~90	-0.0037246	0.0015072	-2.47	0.014	-0.0066853	-0.0007638
laborfo~1990	-0.0020442	0.0045241	-0.45	0.652	-0.0109317	0.0068433
lacking~1990	-0.0074293	0.012461	-0.6	0.551	-0.0319085	0.01705
medyear~1990	0.0082879**	0.003433	2.41	0.016	0.0015439	0.015032
popdens~1990	-0.0000263	0.0000327	-0.8	0.422	-0.0000906	0.0000379
unemplo~1990	0.0142542	0.0138693	1.03	0.305	-0.0129916	0.0414999
bachelor1990	0.0112778	0.0082254	1.37	0.171	-0.0048808	0.0274364
lnpercapit~1	-0.6327732**	0.2186459	-2.89	0.004	-1.062296	-0.2032505
hhwithe~1990	-0.015224***	0.0042565	-3.58	0	-0.0235863	-0.0068628
lnpopulati~1	0.040849**	0.01878	2.18	0.03	0.0039564	0.0777416
inpo~1001990	-0.007348*	0.0042786	-1.72	0.086	-0.0157531	0.0010571
vacanth~1990	0.0017033	0.0035173	0.48	0.628	-0.0052063	0.008613
lnmedianho~1	0.0300648	0.1125167	0.27	0.789	-0.1909705	0.2511001
rucacod~2006	-0.0057331	0.0097629	-0.59	0.557	-0.0249119	0.0134457
fundingrec~o	0.0480678	0.0544896	0.88	0.378	-0.0589753	0.1551109
_cons	-9.799286	6.867631	-1.43	0.154	-23.29052	3.69195

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D14. OLS Regression for In Poverty Under 1.00 (2000-1990)

Linear regression

Number of obs =	**547**
F(17, 529) =	**3.63**
Prob > F =	**0.0000**
R-squared =	**0.0854**
Root MSE =	**.54107**

lninpove~100	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	0.0006664	0.0017386	0.38	0.702	-0.0027489	0.0040818
otherra~1990	0.00339	0.0024059	1.41	0.159	-0.0013363	0.0081163
travel15m~90	-0.0015206	0.0022925	-0.66	0.507	-0.0060242	0.002983
laborfo~1990	-0.0105121	0.0050175	-2.1	0.037	-0.0203687	-0.0006555
lacking~1990	0.0145333	0.0096058	1.51	0.131	-0.0043369	0.0334034
medyear~1990	0.0011626	0.0042449	0.27	0.784	-0.0071765	0.0095016
popdens~1990	0.0000743*	0.0000398	1.86	0.063	-3.99E-06	0.0001525
unemplo~1990	-0.021929	0.0136776	-1.6	0.109	-0.048798	0.00494
bachelor1990	0.0163383*	0.0099033	1.65	0.1	-0.0031163	0.0357929
lnpercapit~1	0.4038558**	0.1750641	2.31	0.021	0.0599496	0.747762
hhwithe~1990	0.0068816	0.003854	1.79	0.075	-0.0006894	0.0144526
hhwiths~1990	-0.0040672	0.0052725	-0.77	0.441	-0.0144248	0.0062904
lnpopulati~1	-0.001886	0.0246189	-0.08	0.939	-0.0502487	0.0464768
vacanth~1990	0.0008877	0.0032487	0.27	0.785	-0.0054942	0.0072696
lnmedianho~1	0.0444017	0.1066939	0.42	0.677	-0.1651941	0.2539975
rucacod~2006	0.0067107	0.0084282	0.8	0.426	-0.009846	0.0232675
fundingrec~o	-0.0054169	0.0434496	-0.12	0.901	-0.0907717	0.079938
_cons	-6.524242	8.123942	-0.8	0.422	-22.48339	9.434905

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D15. OLS Regression for Vacant Housing Units (2000-1990)

Linear regression						**Number of obs =**	**551**
						F(17, 533) =	**3.91**
						Prob > F =	**0.0000**
						R-squared =	**0.1290**
						Root MSE =	**.47115**
lnvacantho~s	|	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	|	-0.0011828	0.0032544	-0.36	0.716	-0.0075757	0.0052101
otherra~1990	|	0.0043126	0.0022722	1.9	0.058	-0.0001511	0.0087762
travel15m~90	|	0.0009851	0.0014486	0.68	0.497	-0.0018605	0.0038307
laborfo~1990	|	0.0009072	0.0039263	0.23	0.817	-0.0068058	0.0086202
lacking~1990	|	-0.0172369*	0.0091596	-1.88	0.06	-0.0352304	0.0007565
medyear~1990	|	-0.0031337	0.0031595	-0.99	0.322	-0.0093404	0.0030729
popdens~1990	|	-0.000085**	0.0000331	-2.57	0.011	-0.0001501	-0.00002
unemplo~1990	|	0.0135524	0.0124953	1.08	0.279	-0.0109937	0.0380984
bachelor1990	|	0.0042542	0.0074858	0.57	0.57	-0.0104512	0.0189596
lnpercapit~1	|	0.2002123	0.1712037	1.17	0.243	-0.1361045	0.5365291
hhwithe~1990	|	-0.0039667	0.0042005	-0.94	0.345	-0.0122183	0.004285
hhwiths~1990	|	-0.0029684	0.0036579	-0.81	0.417	-0.0101541	0.0042172
inpo~1001990	|	0.0016148	0.0033788	0.48	0.633	-0.0050226	0.0082522
lnpopulati~1	|	0.0768927**	0.0269105	2.86	0.004	0.0240292	0.1297563
lnmedianho~1	|	-0.3020449**	0.1157889	-2.61	0.009	-0.5295035	-0.0745862
rucacod~2006	|	0.0093189	0.0088255	1.06	0.291	-0.0080181	0.0266559
fundingrec~o	|	-0.0063692	0.0433243	-0.15	0.883	-0.0914766	0.0787382
_cons	|	6.791864	6.015275	1.13	0.259	-5.024691	18.60842

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table D16. OLS Regression for Median House Value (2000-1990)

Linear regression						**Number of obs =**	**564**
						F(17, 546) =	**2.37**
						Prob > F =	**0.0016**
						R-squared =	**0.1127**
						Root MSE =	**.251**
lnmedianho~e	|	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
black1990	|	-0.0006724	0.001461	-0.46	0.646	-0.0035422	0.0021974
otherra~1990	|	-0.0003333	0.0012865	-0.26	0.796	-0.0028604	0.0021939
travel15m~90	|	-0.0008512	0.0008356	-1.02	0.309	-0.0024926	0.0007901
laborfo~1990	|	-0.0037089*	0.0021756	-1.7	0.089	-0.0079825	0.0005648
lacking~1990	|	-0.003363	0.0061239	-0.55	0.583	-0.0153922	0.0086662
medyear~1990	|	0.0004462	0.0017194	0.26	0.795	-0.0029313	0.0038238
popdens~1990	|	-0.000013	0.000016	-0.81	0.418	-0.0000444	0.0000185
unemplo~1990	|	-0.0051535	0.0068725	-0.75	0.454	-0.0186533	0.0083463
bachelor1990	|	-0.0038906	0.0042971	-0.91	0.366	-0.0123316	0.0045504
lnpercapit~1	|	0.0473162	0.0827761	0.57	0.568	-0.1152825	0.2099149
hhwithe~1990	|	-0.0024141	0.0021103	-1.14	0.253	-0.0065594	0.0017313
hhwiths~1990	|	-0.0027363	0.0020262	-1.35	0.177	-0.0067164	0.0012439
inpo~1001990	|	0.0011594	0.0018942	0.61	0.541	-0.0025614	0.0048802
vacanth~1990	|	-0.0043211**	0.0019584	-2.21	0.028	-0.008168	-0.000474
lnpopulati~1	|	0.0092393	0.0107649	0.86	0.391	-0.0119064	0.0303849
rucacod~2006	|	-0.0066233	0.0047198	-1.4	0.161	-0.0158944	0.0026479
fundingrec~o	|	0.0041454	0.0229234	0.18	0.857	-0.0408834	0.0491742
_cons	|	-0.3893727	3.502025	-0.11	0.912	-7.268464	6.489718

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

APPENDIX E. Full Logistic Regressions Results forATE - ***Table E1. ATE logistic regression (2009-1990)***

Logistic regression	Number of obs	=	564
	LR chi2(17)	=	60.01
	Prob > chi2	=	0
	Pseudo R2	=	0.0946
	Log likelihood	=	-287.15226

fundingrec~o	**Coef.**	**Std. Err.**	**z**	**P>|z|**	**[95% Conf.**	**Interval]**
lnmedianho~3	-1.209709**	0.4842146	-2.5	0.012	-2.158752	-0.2606653
black1990	0.01267	0.008884	1.43	0.154	-0.0047423	0.0300822
otherra~1990	-0.0110234	0.0120718	-0.91	0.361	-0.0346838	0.012637
travel15m~90	0.0182135**	0.0074551	2.44	0.015	0.0036017	0.0328253
laborfo~1990	0.0402869**	0.0187755	2.15	0.032	0.0034877	0.0770861
lacking~1990	-0.0780119*	0.0455969	-1.71	0.087	-0.1673802	0.0113565
medyear~1990	0.0232124	0.0143068	1.62	0.105	-0.0048286	0.0512533
popdens~1990	-0.0001532	0.0001993	-0.77	0.442	-0.000544	0.0002375
unemplo~1990	0.1093145*	0.0631757	1.73	0.084	-0.0145077	0.2331367
bachelor1990	0.0506063	0.0362127	1.4	0.162	-0.0203693	0.1215819
lnpercapit~3	-1.411093*	0.8160547	-1.73	0.084	-3.010531	0.1883449
hhwithe~1990	-0.051287**	0.017742	-2.89	0.004	-0.0860609	-0.0165136
hhwiths~1990	-0.0145037	0.0160272	-0.9	0.365	-0.0459165	0.0169091
inpo~1001990	-0.017097	0.014685	-1.16	0.244	-0.045879	0.0116851
vacanth~1990	-0.0088377	0.0143628	-0.62	0.538	-0.0369883	0.019313
lnpopulati~3	0.1764894	0.1208421	1.46	0.144	-0.0603567	0.4133355
rucacod~2006	0.0345162	0.0402358	0.86	0.391	-0.0443444	0.1133768
_cons	-22.16496	27.66274	-0.8	0.423	-76.38293	32.05302

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

Table E2. ATE Logistic Regression (2000-1990)

Logistic regression			
	Number of obs	=	564
	LR chi2(17)	=	60.01
	Prob > chi2	=	0
	Pseudo R2	=	0.0946
	Log likelihood	=	-287.15226

fundingrec~o	**|**	**Coef.**	**Std. Err.**	**z**	**P>|z|**	**[95% Conf.**	**Interval]**
lnmedianho~1	|	-1.209709**	0.4842146	-2.5	0.012	-2.158752	-0.26067
black1990	|	0.01267	0.008884	1.43	0.154	-0.0047423	0.030082
otherra~1990	|	-0.0110234	0.0120718	-0.91	0.361	-0.0346838	0.012637
travel15m~90	|	0.0182135**	0.0074551	2.44	0.015	0.0036017	0.032825
laborfo~1990	|	0.0402869**	0.0187755	2.15	0.032	0.0034877	0.077086
lacking~1990	|	-0.0780119*	0.0455969	-1.71	0.087	-0.1673802	0.011357
medyear~1990	|	0.0232124	0.0143068	1.62	0.105	-0.0048286	0.051253
popdens~1990	|	-0.0001532	0.0001993	-0.77	0.442	-0.000544	0.000238
unemplo~1990	|	0.1093145*	0.0631757	1.73	0.084	-0.0145077	0.233137
bachelor1990	|	0.0506063	0.0362127	1.4	0.162	-0.0203693	0.121582
lnpercapit~1	|	-1.411093*	0.8160547	-1.73	0.084	-3.010531	0.188345
hhwithe~1990	|	-0.0512873**	0.017742	-2.89	0.004	-0.0860609	-0.01651
hhwiths~1990	|	-0.0145037	0.0160272	-0.9	0.365	-0.0459165	0.016909
inpo~1001990	|	-0.017097	0.014685	-1.16	0.244	-0.045879	0.011685
vacanth~1990	|	-0.0088377	0.0143628	-0.62	0.538	-0.0369883	0.019313
lnpopulati~1	|	0.1764894	0.1208421	1.46	0.144	-0.0603567	0.413336
rucacod~2006	|	0.0345162	0.0402358	0.86	0.391	-0.0443444	0.113377
_cons	|	-22.16496	27.66274	-0.8	0.423	-76.38293	32.05302

NOTE: *, **, *** indicates significance at the 10; 5, and 1 percent confidence level, respectively.

APPENDIX F. ATE Results for Grants and Loans

Table F1. Average Treatment Effect Results of Grants dummy variable

Dependent Variable	Short term (1990-2000)				Long term (1990-ACS2009)			
	Nearest Neighbor		Kernel Matching		Nearest Neighbor		Kernel Matching	
	Difference	T-stat	Difference	T-stat	Difference	T-stat	Diff.	T-stat
POP	.039	0.74	.049	0.90	.047	0.71	.059	0.86
MHI	-.067	-1.09	-.008	-0.15	-.082	-0.97	-.043	-0.54
PCI	-.024	-0.36	-.034	-0.72	-.085	-0.89	-.037	-0.44
HHE	-.030*	-1.80	-.015	-1.01	-.005	-0.22	.004	0.20
HHSEI	.049	0.30	.014	0.11	.012	0.11	-.002	-0.02
POV	-.094	-0.94	-.081	-0.84	-.040	-0.32	-.045	-0.43
VHU	-.019	-0.37	-.032	-0.67	.025	0.27	.039	0.46
MHV	-.039	-0.88	-.041	-1.01	.011	1.27	.144*	1.70

NOTE: * indicates significance at the 10 percent confidence level.

Table F2. Average Treatment Effect Results of Loans dummy variable

Dependent Variable	Short term (1990-2000)				Long term (1990-ACS2009)			
	Nearest Neighbor		Kernel Matching		Nearest Neighbor		Kernel Matching	
	Difference	T-stat	Difference	T-stat	Difference	T-stat	Diff.	T-stat
POP	.045	1.00	.053	1.18	.070	1.17	.077	1.26
MHI	.003	0.07	.015	0.35	-.027	-0.40	-.035	-0.50
PCI	-.057	-1.31	-0.49	-1.19	-.058	-0.87	-.086	-1.26
HHE	-.0006	-0.04	.003	0.20	.005	0.29	.006	0.36
HHSEI	.002	0.02	.003	0.03	-.113	-1.21	-.020	-0.24
POV	-.053	-0.63	-.090	-1.07	.012	0.11	-.018	-0.19
VHU	.021	0.47	-.015	-0.37	.035	0.45	.058	0.75
MHV	-.032	-0.81	-.009	-0.26	.115	1.49	.129*	1.76

NOTE: * indicates significance at the 10 percent confidence level.

VITA

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Major Field: Agricultural Economics

Scope and Method of Study: One of USDA Rural Development's most popular programs is the funding for public water and sewer infrastructure projects in rural communities. This study reviews the water infrastructure projects funded in the state of Oklahoma between 1990 and 2000 and evaluates their impact on different measures of economic growth over both the short (1-10 years) and long (10-20 years) term. Evaluation techniques include multivariate regression analysis and average treatment effects with incorporation of propensity scores matching technique.

Findings and Conclusions: Results suggest that while most economic growth measures (population, income levels, and poverty levels) are not impacted by the program, housing values do show a statistically significant increase in communities receiving water infrastructure funding over the long term.

ADVISER'S APPROVAL: Dr. Brian E. Whitacre