APPENDIX R
STROM THURMOND INSTITUTE ECONOMIC ANALYSIS – LAKE KEOWEE

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REGIONAL ECONOMIC ANALYSIS OF CHANGING LAKE LEVELS IN LAKE KEOWEE

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I. STUDY DESCRIPTION

The purpose of this study is to answer the following questions:

- Do changing water levels in Lake Keowee have a measurable impact on the economy and property values in Oconee and Pickens Counties, South Carolina?
- Do different Duke Energy flow scenarios (Lake Keowee to Hartwell Lake) affect water levels in Lake Keowee and Hartwell Lake sufficiently to have a measurable impact on the economy and property values in the surrounding counties?

The genesis of this analysis comes from an earlier study of the regional economic impact of changing water levels in Hartwell Lake on the six county region in South Carolina and Georgia surrounding the lake. Understanding the economic impact of changing water levels in Lake Keowee was considered an important next step, given the importance of both Hartwell Lake and Lake Keowee to the Upper Savannah River Basin.

The project examined selected lake, real estate, and economic data over a period of over 11 years from 1998 to 2009. The two counties bordering Lake Keowee—Oconee and Pickens Counties in South Carolina—comprised the area of study. Lake Keowee data includes monthly average lake level and air temperature. Real estate data are the number of monthly transactions (including sale price and property attributes) on lakefront parcels in Oconee County and on all parcels in Pickens County. Economic data include monthly gross retail sales in selected sectors plus other measures of the local and regional economy. The period of study includes two extended droughts as well as periods of ample rainfall. Flow scenarios from Lake Keowee to Hartwell Lake through Keowee Dam were supplied by Duke Energy consulting engineers.

Standard statistical techniques were used to assess the strength of the relationships between the water level in Lake Keowee and the following variables: real estate sales, property sales prices, and selected categories of gross retail sales. The Regional Dynamics (REDYN) economic modeling engine generated estimates of the overall economic impact of changing lake levels on the study area, including those resulting from different flow scenarios.

II. PROJECT BACKGROUND

LAKE KEOWEE

Lake Keowee is located in Pickens and Oconee Counties in the Upstate of South Carolina. The lake was constructed by Duke Energy as a part of the Keowee-Toxaway Project by damming the Keowee and Little Rivers. Its primary function is to supply cooling water to the Oconee Nuclear Station, although recreation use and real estate development have also become important roles for the lake since its completion in 1971.

Lake Keowee has a surface area of approximately 18,500 acres and 300 miles of shoreline. It is bordered to the north by Lake Jocassee, also a Duke Energy lake, which is used to regulate water levels in Lake Keowee during times of low rainfall. Water levels in Lake Keowee fluctuate five to six feet below full pool (BFP) at most due to Oconee Nuclear Station's inflow requirements. To the south, Lake Keowee is adjacent to Hartwell Lake, a U.S. Army Corps of Engineers (USACE) lake, which is also part of the upper Savannah River Basin. Outflow from Lake Keowee into Hartwell Lake may affect water levels in Hartwell Lake, especially in low flow periods during droughts.

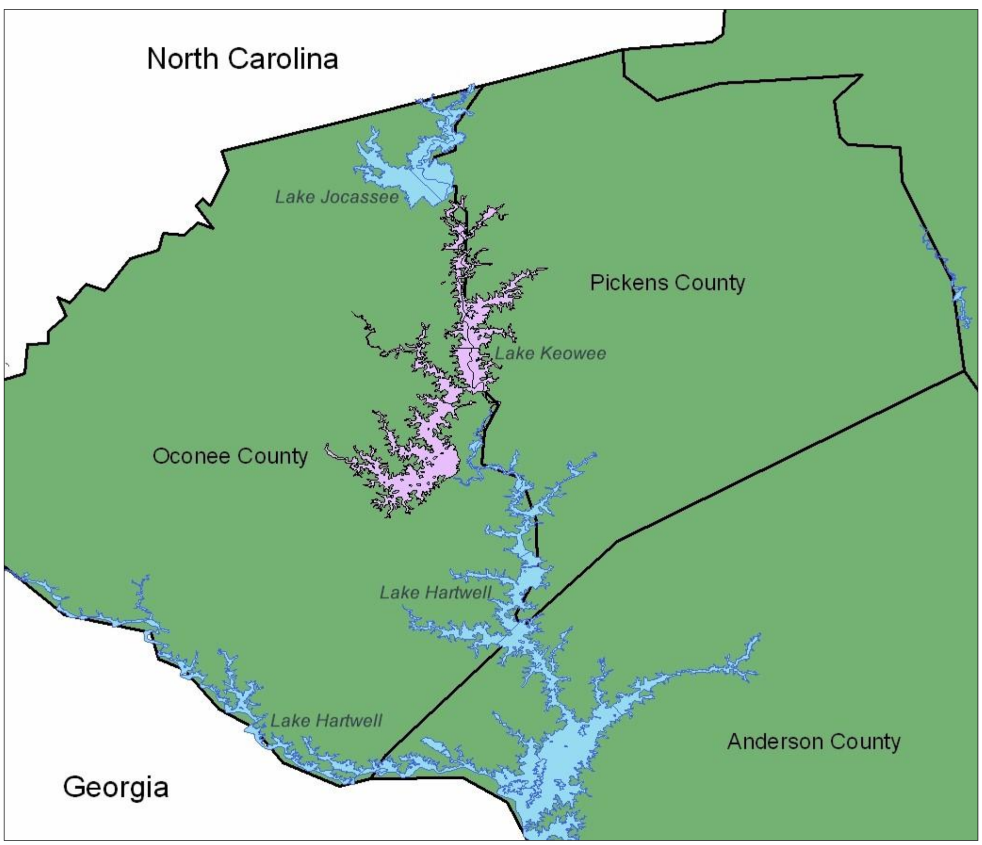

Figure 1: Lake Jocassee, Lake Keowee and Hartwell Lake, South Carolina

III. DATA SOURCES AND METHODOLOGY

DATA SOURCES

The primary independent variable used is Lake Keowee's average monthly water level, or elevation, measured in feet above mean sea level (MSL). Full pool for Lake Keowee is 800 feet above MSL, although Duke Energy typically standardizes full pool for its lakes to 100 feet above MSL. Three dependent variables were used in the analysis:

- Lake-access real estate transactions
- Property value, as measured by sale price
- County gross retail sales

Economic and population data was collected from a variety of local, state, and federal government secondary source material. These variables capture both resident and nonresident economic activity as people from outside of Oconee and Pickens Counties buy homes on the lake, purchase goods and services on or near the lake, and visit lake sites for recreation.

Lake Elevation

Lake Keowee's average monthly elevation for the years 1998 through mid 2010 was provided by Duke Energy. The average monthly temperature at the Greenville-Spartanburg International Airport is used as a seasonal indicator (many boaters prefer warmer to colder air temperatures).

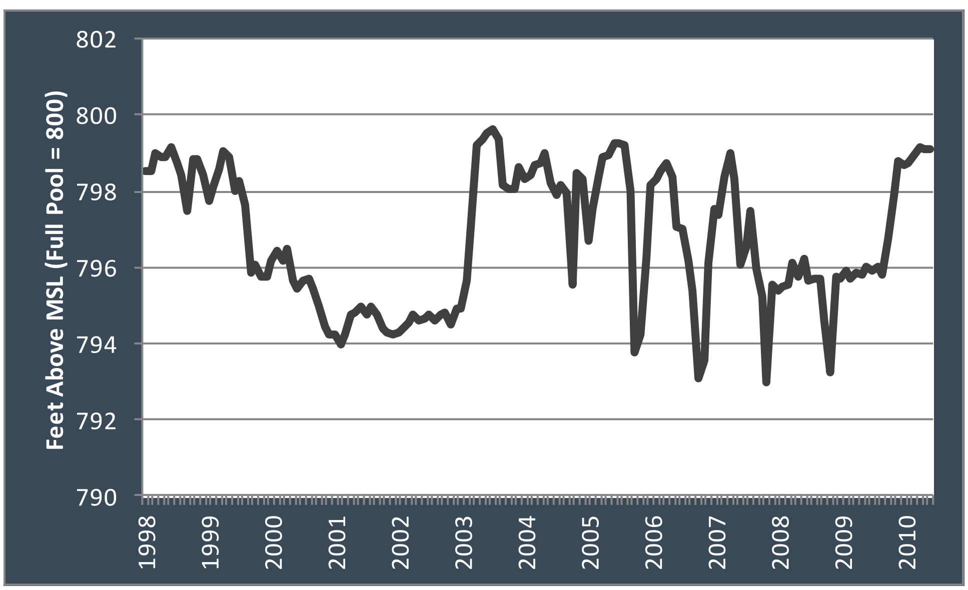

Figure 2: Lake Keowee Elevations

Real Estate Transactions

Real estate data was obtained by first identifying privately-owned parcels with direct access to Lake Keowee within Oconee and Pickens Counties. This data was collected from GIS (Geographical Information System) mapping parcels obtained from county governments. There are 6,841 privately owned parcels bordering Lake Keowee in the two counties.

Once these parcels were identified, county real property records were searched to determine the number of real estate transactions involving these parcels that occurred between January 1998 and May 2009. Over the study period there were 4,474 real estate transactions among 6,841 parcels adjacent to Lake Keowee. Some parcels had multiple transactions during the period.

Table 1: Lake Keowee Real Estate Transactions (lakefront parcels only)

County	January 1998 to May 2009	Total Parcels
Oconee, SC	3,508	4,902
Pickens, SC	966	1,939
Total	**4,474**	**6,841**

County Gross Retail Sales

Data was collected on more than 25 categories of gross retail sales in each of the two counties bordering Lake Keowee. These categories were restricted to business and industry sectors most likely to experience measurable economic impacts resulting from changing lake levels. Ultimately, our analysis focused on data from 12 SIC codes (Table 2).

Table 2: Gross Retail Sales Categories

SIC Code	Category
2099	Retail Trade
5331	General Merchandise
5399	Miscellaneous General Merchandise
5411	Groceries
5511	Cars
5541	Gas Stations
5551, 5599	Boating Stores
5812	Restaurants
5813	Drinking Establishments (Bars)
5921	Liquor Stores
5941	Sporting Goods Stores

Gross retail sales data for South Carolina were obtained from the state’s Department of Revenue (DOR) for five years 2005 to 2009 (data from 1998 to 2004 was unavailable at the level of detail required). The DOR provided the dollar value of total reported monthly sales of all businesses in each county, organized by SIC (Standard Industrial Classification) code. [1]

ANALYTICAL TECHNIQUES

In this study, we first combined several statistical analysis techniques to analyze the strength of the relationship between water levels in Lake Keowee and economic activity in Oconee and Pickens Counties. Second, that information was used with the REDYN economic model to estimate the total economic impact of different water levels in Lake Keowee on the two counties. Third, the Lake Keowee-specific results were combined with results from the 2010 analysis of water levels in Hartwell Lake to assess the regional economic impact of alternative flow scenarios on the six counties that border one or both lakes.

Regression Analysis

Ordinary least squares (OLS) regression analysis was used to directly estimate the strength of the relationship between the water level in Lake Keowee and the following variables: real estate transactions on lakefront parcels, gross sales of goods and services in Oconee and Pickens Counties, and property values (as indicated by sale price) of lakefront parcels. . The basic structure of an OLS linear regression model is as follows:

Model: $y_i = \beta 0 + \beta_1 x_i + \varepsilon_i$, $i = 1 \ldots n$

y_i = dependent variable

x_{i1} = independent variable

β_1 = estimate of change in dependent variable per unit increase in independent variable

i = month

ε_i = error term

One of the benefits of regression analysis is that it separates the effect of each dependent variable analyzed (real estate transactions, gross sales, property values) on the independent variable (water level). Thus, regression analysis can control for economic and seasonal variables that affect gross sales, or real estate sales, but may have no relationship to lake level.

In this study, it was important to remove the effect of seasonal temperature variations on lake-related activity. The variable chosen to remove seasonal variation was average monthly temperature from the Greenville/Spartanburg (GSP) weather reporting station. As well, the nature of the dependent variables made it especially important to control for regional economic conditions, because some recent droughts occurred during periods of economic downturn.

[1] In 1997 the federal government changed its industry classification system to the North American Industrial Classification System (NAICS), but South Carolina only recently changed its reporting from SIC to NAICS.

A wide variety of data was collected to control for economic and seasonal factors. [2] Two state-level economic variables were collected: annual gross state product and quarterly state personal income. County level economic data collected included the following:

- population
- population over 16 years old
- labor force
- mean household income
- median household income
- per capita personal income (Anderson, SC MSA)
- percentage change in per capita personal income
- percentage of population poverty
- population density
- monthly county employment
- monthly annual employment percentage change

Many of these variables did not significantly affect the dependent variables or improve the overall statistical analysis and were therefore not incorporated into our models. The variable coefficients that result serve as inputs into the REDYN model. These coefficients estimate the impact of lake level on each dependent variable analyzed (real estate transactions, gross sales, or property values).

Linear regression analysis requires one to assume that the relationship between the independent variable (lake level) and the dependent variable (gross sales, property values, or real estate transactions) is linear and does not change over the period of analysis. But this assumption may or may not be reasonable. For this reason, linear regression analysis was used as a baseline technique before other approaches were tried.

Preliminary analyses of the relationships between lake level and real estate transactions, housing price, and some categories of gross retail sales suggested that these relationships were not linear. Thus, where appropriate, other model specifications were tested.

For example, these data were tested for the presence of structural breaks. Structural break regression models allow for the analysis of independent variables partitioned into different intervals, or clustered groups. These models are useful when it is hypothesized that there may be unique relationships with dependent study variables at different intervals of the independent variable. For example, one might expect to see a smaller effect on real estate transactions when lake levels are less than one foot below full pool than would be seen if levels were more than five feet below full pool. Our 2010 research on real estate transactions and water levels in Hartwell Lake supported this hypothesis (Allen et al. 2010). However, likely due to the limited range within which Lake Keowee water levels are allowed to vary, no structural breaks were detected in the data.

[2] All data collected is annual unless otherwise stated.

We also tested these data using variable transformations such as quadratic terms to determine if nonlinear model forms better explained the relationships between lake elevation and real estate transactions, gross retail sales, and housing values.

Hedonic Regression Models

Hedonic modeling is one tool that has become a popular method for assessing the value of environmental attributes, both positive and negative. Hedonic models are used to assign a quantifiable value to goods that are not directly exchanged in the marketplace. Clean air, clean water and wildlife are typically not priced in traditional markets but this does not mean that they are without value.

For example, if two lakefront homes are identical in every way except one area of the lake has more shoreline exposure due to declining lake levels, the price differential between these two homes reflects the marginal value associated with lake level, or effectively the value of "full pool." Thus, property on or near the lake, or with lake access, is bought and sold regularly and should reflect the intrinsic value of lake activity and amenities. Hedonic models are able to utilize housing markets as proxies for a wide range of environmental qualities or amenity values (Palmquist et al., 1997). It has been stated that "housing markets are one of the few places where environmental quality is traded" (Palmquist, Roka and Vukina, 1997, p.115).

The hedonic pricing technique, as applied to housing, is based on the idea that the value of a house is a function of the value of individual attributes that comprise the house, such as square footage, number of bedrooms, number of bathrooms, and proximity to such amenities as schools or parks. The price of a house (Ph) can be written as:

$$(1)\quad Ph = f(Sj, Nk, Qm)$$

Where Sj, Nk, and Qm indicate vectors of structural, neighborhood, and other quality variables respectively. Quality variables can represent a range of relevant study features. In this analysis three variables were chosen to represent quality characteristics or water feature variables: Keowee level, Hartwell level, and local average temperature. Given this, Equation 1 represents the hedonic, or implicit price, function for housing. The implicit price of any characteristic, for example Qm, a quality variable, can be estimated as:

$$(2)\quad \delta Ph / \delta Qm = PNk(Qm)$$

This partial derivative gives the change in expenditures on housing that is required to obtain a house with one more unit of Qm, ceteris paribus. If the value of the partial derivative is positive, then the attribute is an amenity. If the value is negative then the attribute is a disamenity, such as air pollution or airport noise.

Economic Impact Analysis

A thorough economic impact analysis attempts to measure direct, indirect and induced economic impacts of a given economic activity. In this project:

> **Direct economic impacts** are spending by residents and visitors to the lake on lake-related activities (boat purchases, boat repairs, gasoline purchases, food purchases, etc.).

Direct spending generates revenue for the recipients to pay wages, income, and taxes to individuals and government in the local economy.

Indirect economic impacts are the wages paid, income received, and tax revenues paid by the recipients of direct lake-related spending that are also spent in the local and regional economy. This spending creates indirect impacts that generate additional wage, income, and tax revenue in the economy.

Induced economic activity occurs as additional local and regional expenditures increase disposable income in the region that further enhances aggregate local and regional demand for goods and services.

Input-output (I/O) models such as REDYN are used to predict the impact of a change in one or more industries on other industries, consumers, and governments. [3] I/O models estimate direct, indirect, and induced economic impacts. Currently the largest model of the United States economy ever built, REDYN utilizes 7.6 terabytes of data to forecast a baseline level of activity within over 800 Standard Occupation Classification (SOC) and 703 North American Industry Classification System (NAICS) sectors. It also considers distance-to-market and transportation costs in determining the supply and demand of commodities across geographic regions. Changes to employment, income, or demand for products or services by either the private or the public sector can be input to the model. Based on these inputs, the model generates an estimate of the resulting variation from the projected baseline due to direct, indirect, and induced effects, as well as the effects on every industry.[4]

Results from the linear and nonlinear statistical models described above were used as inputs to the REDYN model to estimate the total economic impact of changing water levels on the two counties bordering Lake Keowee. These statistical models yielded estimates of the marginal changes to the value of goods and services in selected industry sectors as a result of changing lake levels. When these estimates are entered into the REDYN model, it generates the predicted impact of changing water levels on the regional economy. Methodologically, this twofold approach to the analysis, along with the choice of variables used to estimate economic activity, provide for a thorough and instructive approach to estimating the impact of different lake water levels on overall economic activity.

[3] IMPLAN and REMI are other widely-used Input-Output modeling systems.
[4] In order to enter study data into the REDYN model, a detailed crosswalk was used to convert all gross sales figures from SIC codes used in the study to NAICS codes used in REDYN.

IV. LAKE KEOWEE REAL ESTATE TRANSACTIONS

A chart plotting monthly lakefront real estate transactions in Pickens and Oconee Counties with average monthly water levels in Lake Keowee suggests that there may be a relationship between the two variables (Figure 3). On the other hand, the season, local economic conditions, and other factors can also affect real estate activity. This is why OLS regression analysis was used to isolate the effect of water level on lakefront property sales from these other factors. Real estate and lake level data were analyzed over the period from January 1998 to May 2009.

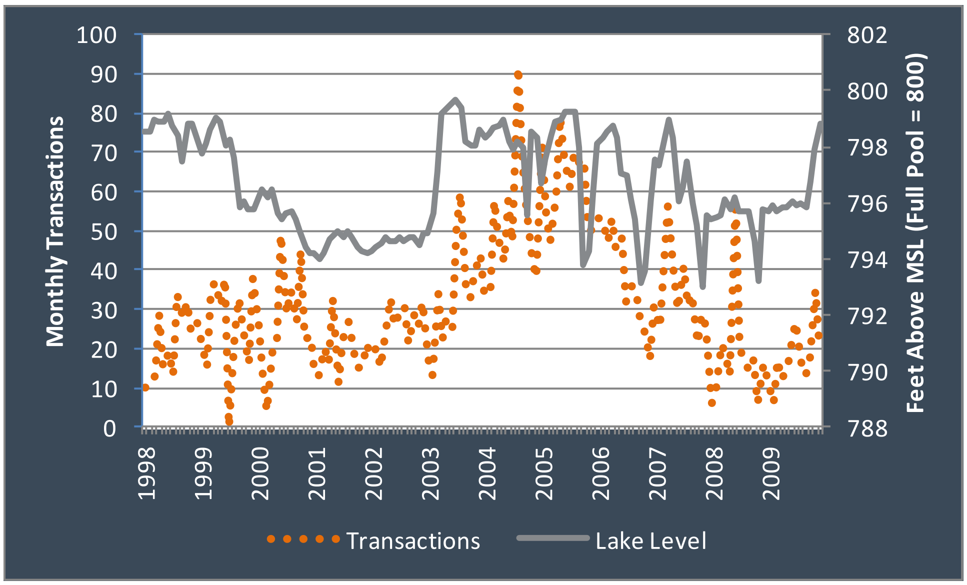

Figure 3: Keowee Elevations vs. Real Estate Transactions

MODEL ONE: OCONEE COUNTY

Model results testing the linear relationship between Lake Keowee's water level and lakefront real estate transactions in Oconee County are illustrated in Tables 3 and 4. The basic structure of the OLS linear regression model is as follows:

Model: $y_i = \beta_0 + \beta_1 x_{\mathbf{i1}} + \beta_2 x_{i2} + \varepsilon_i$, $i = 1 \ldots n$

y_i = dependent variable (real estate transactions,)

x_{i1} = independent variable (lake level)

x_{i2} = independent control variables (per capita personal income, temperature, etc.)

β_1 = estimate of change in dependent variable per unit increase in lake level, all controls held constant

β_2 = estimate of change in dependent variable per unit increase in control variable, lake level held constant i = month

ε_i = error term

The model controls for several economic and demographic characteristics that also influence the volume of real estate transactions in a region. Model results reveal statistically significant relationships for temperature, the percent of county residents in poverty, and Lake Keowee water level.

The lake's elevation also has a positive statistically significant relationship with lakefront real estate transactions. Oconee County loses almost three transactions per month for every foot the lake falls below full pool (BFP) and vice versa. The R-squared of 0.6387 indicates that approximately 64 percent of the variation in Oconee County lakefront real estate transactions over the analysis period can be explained by this model.

Table 3: OLS Model Results: Oconee County Transactions

Summary of Fit	
R-square	0.657762
R-square Adj	0.638749
Analysis of Variance	
F Ratio	34.595
Prob > F	<.0001

Table 4: Parameter Estimates: Oconee County Transactions

Term	Estimate	t Ratio	Prob>|t|
Intercept	-273.1124	-4.14	<.0001
Time_index	2.0825533	2.86	0.0053
avgtemp	0.2352164	2.7	0.0083
Keo_level	2.9814536	4.12	<.0001
Oconee%Pov	-3.754879	-3.95	0.0002
Time_index*oc_pci	-4.84E-05	-2.27	0.0257

Model One: Pickens County

Tables 5 and 6 illustrate the results of a standard OLS regression model testing the relationship between lakefront real estate sales transactions in Pickens County located on Lake Keowee and Lake Keowee elevations. Water level has a positive, statistically significant relationship with Pickens County real estate transactions. Pickens County loses almost one transaction per month for every foot the lake falls BFP and vice versa. An R-squared of 0.189 indicates that approximately 19 percent of the variation in Pickens County lakefront real estate transactions over the analysis period can be explained by this model.

Table 5: OLS Model Results: Pickens County Transactions

Summary of Fit	
R-square	0.18904
R-square Adj	0.1716
Root Mean Square Error	6.883472
Mean of Response	8.552083
Observations (or Sum Wgts)	96
Analysis of Variance	
F Ratio	10.8395
Prob > F	<.0001

Table 6: Parameter Estimates: Pickens County Transactions

Term	Estimate	t Ratio	Prob>|t|
Intercept	-85.68699	-2.31	0.0234
Keo_level	0.9224254	2.37	0.0196
PickensIncome2	1.689537	3.34	0.0012

MODEL TWO: PICKENS COUNTY

The low R-square in the initial model estimation for Pickens County suggested the need for alternative model estimation. Examination of the distribution of the residuals from OLS estimation provided evidence that the error terms were not normally distributed. Violations of normality may compromise the estimation of coefficients and the calculation of confidence intervals. In such cases, a nonlinear transformation of appropriate variables may cure this problem. Given the distribution of real estate transactions over the period, a log-linear model was chosen for further examination.

The basic structure of a log linear regression model is as follows:

Model: $\log(y)_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \varepsilon_i$, $i = 1 \ldots n$

y_i = log dependent variable (real estate transactions)

x_{i1} = independent variable (lake level)

x_{i2} = independent control variables (per capita personal income, temperature, etc.)

β_1 = estimate of change in dependent variable per unit increase in lake level, all controls held constant

β_2 = estimate of change in dependent variable per unit increase in control variable, lake level held constant

i = month

ε_i = error term

Tables 7 and 8 provide results for the log-linear model testing the testing the relationship between logged Pickens County real estate transactions and Lake Keowee water level. Water level has a positive, statistically significant relationship with lakefront real estate transactions in Pickens County.

Interpretation of coefficients from log linear models is more complex than for traditional OLS coefficients. Interpretation requires exponentiation of each coefficient. For lake level, exp (□1) = 1.078. For the variable, Lake Keowee water level, a 1.0 foot decline in water level results in 7.8 lost real estate transactions. The R-squared of 0.512 provides evidence that the log-linear model has more goodness of fit than the traditional OLS model (0.19). We conclude that this model describes approximately 51 percent of the variation in lakefront real estate transactions in Pickens County.

Table 7: Log-Linear Model Results: Pickens County Transactions

Summary of Fit	
R-square	0.512009
R-square Adj	0.490479
Root Mean Square Error	0.51706
Mean of Response	2.090175
Observations (or Sum Wgts)	72
Analysis of Variance	
Source	**Sum of Squares**
Model	19.074594
Error	18.179853
C. Total	37.254447

Table 8: Parameter Estimates: Pickens County Transactions

Term	Estimate	t Ratio	Prob>|t|
Intercept	-5.972029	-1.84	0.0699
Keo_level	0.0753088	2.23	0.029
PickensIncome2	0.2154001	4.69	<.0001
pick_d_emp	0.1233701	4.96	<.0001

REAL ESTATE TRANSACTIONS SUMMARY

Changing water levels in Lake Keowee have a statistically significant effect on the number of lakefront real estate transactions in both Oconee and Pickens Counties. Falling lake levels correlate with fewer real estate sales, while rising lake levels with more sales. The effect is larger in Oconee County, likely due to the larger number of lakefront parcels overall in that county. The relationship found in our models indicates that an increase of one foot in the elevation of Lake Keowee increases the number of real estate transactions by approximately three in Oconee County and one in Pickens County.

On average, between January 1998 and May 2009, 24 lakefront parcel transactions took place per month in Oconee County and seven in Pickens County. The impact of a one-foot change in water level therefore amounts to monthly change in sales of lakefront parcels of approximately 12 percent in Oconee County and 14 percent in Pickens County.

V. Gross Retail Sales and Lake Elevations

We continued our analysis by examining the strength of the relationship between county-level spending and water levels in Lake Keowee. Monthly gross retail sales were selected as the appropriate data to capture variation in local spending resulting from changing lake levels. We obtained data from the South Carolina DOR for the years 2005 through 2009.

Gross retail sales are a good measure of county economic activity, particularly at the consumer level. It encompasses spending increases (or declines) resulting from changes in income and employment, and also captures spending by visitors to the region. Gross retail sales are the dollar value of sales before state and local taxes are applied.

Table 9: Total Economic Activity 2007

County	Gross Retail Sales ($ millions)
Oconee, SC	932
Pickens, SC	1,265
Total	**2,197**

Linear Models

Linear regression models, with each gross sales category as the dependent variable and water level as the primary independent variable, were used to estimate the relationship between sales and water level in Lake Keowee. Average monthly temperature and county per capita income were included in the models as control variables for seasonal variations and local economic conditions. County gross retail sales in 12 SIC codes were evaluated against lake elevations (Table 2).

We expected that certain gross sales categories would be more likely than others to exhibit a statistically significant relationship with Lake Keowee water levels. We also anticipated that these relationships might vary in direction and magnitude. For example, the dollar volume of boat sales might naturally vary with lake level—up when the lake is close to full pool and down when the lake is much lower. Other categories, such as groceries and general merchandise, were more difficult to predict.

The results of these linear regression models revealed that lake level is statistically significantly correlated with only a few of the gross sales categories in each county. For Oconee and Pickens Counties, the only categories to exhibit a statistically significant relationship with the level of Lake Keowee were grocery and general merchandise sales.

But these results also hinted at two possible levels of complexity in the relationship between water levels in Lake Keowee and county gross retail sales: substitution effects between nearby lakes and/or nonlinearity. The proximity of Lake Keowee to Hartwell Lake could cause some lake users to favor one lake over the other depending on water levels. Such behavior would likely affect the level and pattern of gross sales as levels in the two lakes vary. In addition, if the relationship between lake level and gross sales is nonlinear, then the linear regression models used would not correctly describe that relationship.

SUBSTITUTION EFFECTS BETWEEN LAKE KEOWEE AND HARTWELL LAKE

Hartwell Lake is a United States Army Corps of Engineers lake that borders Oconee and Pickens Counties to the south and west of Lake Keowee. Because Lake Keowee was constructed by Duke Energy to meet the cooling requirements of the Oconee Nuclear Station, the lake is not allowed to fall below a certain level, about five feet to six feet below full pool. Duke Energy also uses Lake Jocassee, another Duke Energy lake located just north of Lake Keowee, to regulate Keowee's elevations.

Hartwell Lake, on the other hand, is a part of USACE's Savannah River management area, so that some of its sequestered water must be released regularly to maintain levels in Richard B. Russell and J. Strom Thurmond Lakes, which are downstream from Hartwell Lake, as well as to maintain flow in the lower Savannah River. As a result, water levels in Lake Keowee tend to remain more stable over time than Hartwell Lake, including during the drought periods included in the data for this report (Figure 4).

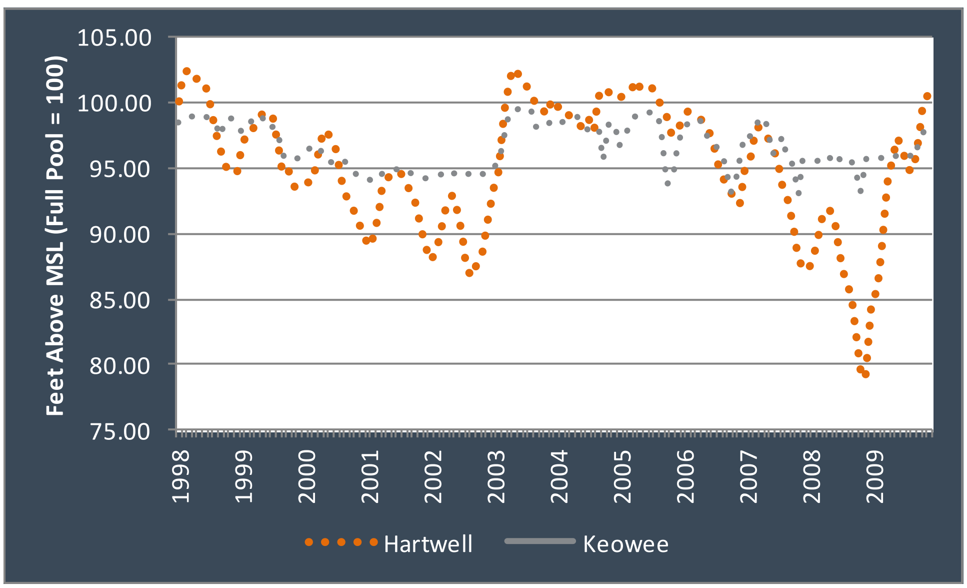

Figure 4: Keowee and Hartwell Elevations

Both Lake Keowee and Hartwell Lake have shoreline bordering Oconee and Pickens Counties. We hypothesized that Lake Keowee could provide competition for Hartwell Lake in terms of recreation use, especially when Hartwell Lake was well below full pool. Conversations with area residents, fisherman, and boaters support this hypothesis. If these two lakes substitute for each other, then spending by area residents and tourists could reveal this behavior.

A range of models were used to test for the presence of substitution between Lake Keowee and Hartwell Lake in Oconee and Pickens Counties. In order to gauge the impact that changing water levels in Lake Keowee have on gross sales in the region, it is necessary to hold constant for Hartwell Lake's lake levels. These relationships were modeled using linear regression models that included an interaction term for water levels in Lake Keowee and Hartwell Lake. The dependent variable in these models was percentage change in water level, which had to be converted to per-foot change in water level before being entered into the REDYN model.

Although linear statistical models tested as the appropriate functional form for several of the relationships between Lake Keowee elevations and gross sales, other relationships exhibited nonlinear characteristics. After graphing these relationships, it appeared that the inclusion of quadratic terms would model these characteristics. We used squared terms for both Keowee and Hartwell elevations in models where nonlinear characteristics appeared.

The model output isolates the impact on county gross sales as lake levels change. The way the models are specified using interaction terms holds one lake level constant while estimating the impact on gross sales from lake level changes in the second lake. The choice of linear or nonlinear model form assured the best possible description of the fit between each individual gross sales category and lake level.

The analysis showed that Oconee and Pickens Counties had statistically significant substitution effects between gross sales and lake levels in Lake Keowee and Hartwell Lake. Accounting for these effects allowed for more accurate prediction equations. Estimates using these gross sales predictions are presented in Table 10. These then served as input to the REDYN economic modeling system for additional analysis.

Table 10: Marginal Impact on Monthly Gross Sales (per one percent change in Keowee elevation)

Oconee County	
Grocery Stores	$423,630
General Merchandise	$241,270
Pickens County	
General Merchandise	$1,369,050

GROSS RETAIL SALES: SUMMARY

The results of these different statistical models reveal that there is a statistically significant relationship between lake elevation and economic activity and—as defined by county-level gross retail sales—in the two counties bordering Lake Keowee. However, the nature of this relationship is complex and its predictive ability is limited. Economic activity in any county is affected by a diverse set of conditions and it is difficult to control for all of these conditions within a statistical model. County-level gross sales data does not fully capture all of the economic activity related to lake activity and water level. Thus, some aspects of the relationship between gross sales and water level may be obscured. An additional and major limitation to our analysis was having access to only five years of gross sales data for South Carolina counties.

VI. Estimated Economic Impact of Lake Elevations

The overall economic impact of changing water levels in Lake Keowee was estimated for Oconee and Pickens Counties using input-output (I/O) analysis. Results from the linear and nonlinear regression models for real estate transactions and gross retail sales (described earlier in this report) were input into the REDYN modeling system. These results were used by REDYN to estimate economic impacts on each county resulting from the income generated by real estate transactions and the changes in gross sales that could be attributed to changes in Lake Keowee's water level.[5] The REDYN model provides an estimate of the total impact of changing lake levels on the broader economy, including direct, indirect, and induced effects.

Monthly Economic Impacts

The REDYN model generates estimated annual economic impacts as four measures: employment, output, disposable income, and net government revenue. In this analysis:

> **Employment** is the total number of jobs (including full and part time) gained or lost in the county associated with a one-foot increase in lake level;
>
> Output is the dollar value of all goods and services produced within the county in a given year associated with a one-foot increase in lake level;
>
> **Disposable income** is the change in aggregated (summed across all households) household after-tax income in a given year associated with a one-foot increase in lake level, and
>
> **Net government revenue** is the change in total revenue received by local (county and municipal) governments in each county, less expenses in a given year associated with a one-foot increase in lake level. These revenues are from all sources, including all taxes, licensing, and fees.

Because of the near-daily variation in Lake Keowee's water level, analyzing the economic impact for an entire year would obscure a great deal of detail. Therefore, we converted results from the I/O model to monthly estimates based on correlation with average monthly lake levels.

Table 11 contains estimates of the median monthly impact of a one-foot increase in Lake Keowee water level in each county on output, income, and net government revenue. These results apply only when Lake Keowee is below full pool. Reversing the signs yields estimates of the monthly economic impact of a one-foot decrease in the water level below full pool.

[5] Real estate income was quantified in terms of estimated real estate commissions and government revenue from taxes and fees.

Table 11: Median Monthly Impact of a One-Foot Increase in Elevation

County	Employment (FTEs per mo.)	Output ($ per mo.)	Disposable Income ($ per mo.)	Net Revenue ($ per mo.)
Oconee	0.31	$277,826	$76,850	$8,678
Pickens	0.39	$205,944	$70,685	$8,894
Total	**0.69**	**$483,770**	**$147,534**	**$17,571**

No county is an island. Economic impacts from one county will naturally spill over into the surrounding counties, be they positive or negative. These cross-county effects are very important in estimating the overall impact of lake level changes on the regional economy. Therefore, effects in Oconee County from changing levels in Lake Keowee impact the economy in Pickens County, and vice versa. The REDYN model takes these factors into account when estimating the overall impact numbers.

Of the two counties bordering the lake, Oconee shows the largest estimated impact on output from changes in Lake Keowee water levels. This is likely due to the closer proximity of commercial areas in and around the town of Seneca to the lake, whereas no such commercial areas are near the lake in Pickens County. Every foot increase in lake level toward full pool increases median monthly employment in Oconee County by the equivalent of 0.4 jobs (or 3.7 jobs on an annualized basis), and median monthly county output by about $277,800. County and municipal governments benefit by a total of $8,700 monthly for every foot increase in Keowee lake level.

While impacted by lake elevation changes less than Oconee County, Pickens County also realizes a positive economic impact when Lake Keowee's water level rises toward full pool. For every foot increase, Pickens County employment increases by an estimated 0.5 job equivalents per month (4.6 jobs on an annualized basis), and by $205,900 in output per month. Local governments in Pickens County receive an additional $8,900 per month in net revenue for every foot increase in water level. Annual estimated economic impacts from real estate transactions and gross sales are below (Tables 12, 13 and 14).

Table 12: Impact of a One Foot Increase in Elevation on Gross Sales

Employment	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oconee County	0.7	0.7	1.1	1.4	1.4	1.9	2.0	2.4	1.4
Pickens County	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.4
Total	**1.0**	**1.0**	**1.4**	**1.8**	**1.8**	**2.4**	**2.5**	**2.9**	**1.8**
Output ($1000s)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Oconee County	95.3	95.8	95.9	95.9	95.8	95.8	95.8	95.7	95.7
Pickens County	178.6	178.8	179.0	179.0	179.1	179.1	179.2	179.2	179.2
Total	**273.9**	**274.6**	**274.8**	**274.9**	**274.9**	**274.9**	**274.9**	**274.9**	**274.9**
Disposable Income ($1000s)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Oconee County	45.6	46.7	47.4	47.7	47.9	48.0	48.1	48.1	48.2
Pickens County	58.5	59.1	60.0	60.4	60.6	60.7	60.8	60.9	60.9
Total	**104.1**	**105.8**	**107.4**	**108.1**	**108.5**	**108.7**	**108.9**	**109.0**	**109.1**
Net Local Fiscal ($1000s)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Oconee County	6.2	5.6	5.1	5.1	5.1	5.2	5.3	5.3	5.4
Pickens County	8.7	7.9	7.1	7.2	7.3	7.4	7.4	7.5	7.6
Total	**14.9**	**13.5**	**12.2**	**12.3**	**12.4**	**12.6**	**12.7**	**12.8**	**12.9**

Table 13: Impact of a One Foot Increase in Elevation on Real Estate Sales

Employment	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oconee County	0.7	0.7	1.1	1.4	1.4	1.9	2.0	2.4	1.4
Pickens County	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.4
Total	**1.0**	**1.0**	**1.4**	**1.8**	**1.8**	**2.4**	**2.5**	**2.9**	**1.8**
Output ($1000s)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Oconee County	105.8	86.8	125.4	168.3	168.3	235.6	256.7	306.7	185.2
Pickens County	20.2	18.1	22.6	25.7	27.1	32.1	32.6	36.2	27.7
Total	**125.9**	**104.8**	**148.0**	**194.0**	**195.4**	**267.7**	**298.4**	**342.9**	**212.9**
Disposable Income ($1000s)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Oconee County	16.3	14.6	21.0	27.8	27.6	38.0	40.9	48.4	29.3
Pickens County	6.4	5.8	7.9	10.0	10.1	13.3	14.1	16.4	10.6
Total	**22.7**	**20.4**	**28.9**	**37.7**	**37.6**	**51.2**	**55.0**	**64.8**	**39.8**
Net Local Fiscal ($1000s)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Oconee County	2.2	1.7	2.4	3.2	3.0	4.3	4.7	5.5	2.9
Pickens County	1.0	0.8	1.0	1.3	1.2	1.7	1.8	2.1	1.2
Total	**3.2**	**2.5**	**3.3**	**4.5**	**4.3**	**6.0**	**6.4**	**7.6**	**4.1**

Table 14: Impact of a One Foot Increase in Elevation on Gross Sales + Real Estate Sales

Employment	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oconee County	3.8	3.7	3.2	3.5	3.4	3.9	4.0	4.3	3.3
Pickens County	7.2	6.8	4.1	4.1	3.9	4.0	3.9	3.9	3.7
Total	**11.0**	**10.5**	**7.3**	**7.6**	**7.3**	**7.9**	**7.9**	**8.2**	**7.0**

Output ($1000s)	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oconee County	201.0	182.5	221.3	264.2	264.2	331.4	352.5	402.4	280.9
Pickens County	198.8	196.9	201.5	204.7	206.2	211.2	211.8	215.4	206.9
Total	**399.8**	**379.4**	**422.9**	**468.9**	**470.4**	**542.6**	**564.3**	**617.9**	**487.9**

Disposable Income ($1000s)	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oconee County	61.9	61.3	68.4	75.5	75.5	86.0	89.0	96.6	77.4
Pickens County	64.9	64.9	67.9	70.3	70.6	74.0	74.9	77.2	71.5
Total	**126.8**	**126.2**	**136.3**	**145.9**	**146.1**	**160.0**	**163.9**	**173.8**	**148.9**

Net Local Fiscal ($1000s)	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oconee County	8.4	7.3	7.4	8.3	8.2	9.5	9.9	10.8	8.3
Pickens County	9.7	8.6	8.1	8.5	8.5	9.1	9.2	9.6	8.8
Total	**18.1**	**15.9**	**15.5**	**16.7**	**16.7**	**18.6**	**19.1**	**20.4**	**17.1**

VII. HOUSING PRICES AND LAKE ELEVATIONS

Hedonic modeling is often used to evaluate the impact of amenities (golf courses, green space, school quality, etc.) and disamenities (airport and highway noise, landfills, etc.) on the value of nearby housing. But it has also been used to measure the impact of water quality on property values (Brashares, 1985; David, 1968; Feenberg and Mills, 1980; Michael et al., 2000; and Young and Teti, 1984). Much of this research indicates that water quality variables which are physically observable to residents yield the strongest correlations with property values. Brashares (1985) concludes that when water quality characteristics are not physically observable they are less likely to be capitalized into property values.

Michael et al. (2000) discuss the importance of individual perceptions of water quality events and their impact on implicit housing prices. Historical water quality conditions may create stickiness in housing prices that may not be observed from characteristics at the time of sale. Additionally, events that are perceived as temporary may not be capitalized into property values when compared against events that are longer term or permanent. A recent study (Carey and Leftwich, 2007) found that a 1999 algal bloom event did not result in significant impacts on lake property values in the years following. It is hypothesized that when negative environmental events are deemed temporary, or isolated, they are not internalized in the market value of property.

A number of hedonic studies have evaluated the impact of water's aesthetic and recreational properties on local property values (Brown and Pollakowski, 1977; D'Arge and Shogren, 1989; Darling, 1973; David, 1968; Feather et al., 1992; Knetsch, 1964). A common finding among these studies is that proximity to water source and the size of lake (water) frontage increase property values.

Lansford and Jones (1995a) find that lake proximity is the most important contributor to a lake's aesthetic and recreation value. The lake's value falls rapidly as the distance from it increases. They estimate that approximately 87 percent of the recreation and amenity value of the lake can be captured in the sale price of homes that are within 2,000 feet of the shoreline. In another study, Lansford and Jones (1995b) confirm that scenic view, waterfront location and water level are all statistically significant contributors to enhanced property values. While proximity to the lake makes the most substantial impact on housing prices, consumers do appear to exhibit a positive preference for higher water levels as capitalized in the value of homes.

In a more recent analysis, Cho et al. (2006) uses spatial weights to evaluate the importance of distance to a water feature and its impact on property value. These results confirm that residential properties closer to specific types of water features will realize a price premium.

LAKE KEOWEE HEDONIC MODELS

In these models, census block variables were used to represent a range of neighborhood characteristics. Census block data includes median household income, median year built, and median home value, which provide important additional statistical controls for local economic and home values. Variables representing proximity to the nearest city are also included. Many of these lakefront residences are located in the mountains of Upstate South Carolina and can be quite far from necessary amenities.

Finally, this analysis also incorporates a range of indicator variables representing distance to elementary, middle, and high schools, and distance to local golf courses. The summary statistics for the variables used in this analysis are provided in Tables 15 and 16. Structural characteristics of homes were chosen in an effort to avoid omitted variable bias. Location attributes or other neighborhood characteristics are commonly used to control for other local amenities.

However, data availability and consistency remain a problem in this data set. In Oconee County, only lakefront parcels were included in the model due to data availability. In Pickens County, we were able to obtain data for all parcels in the county in order to more fully model that county's real estate market and the impact of lake elevations on lakefront home prices.

Measuring the importance of water level, and specifically the impact of declining water levels, on these communities is the variable of interest in this analysis. Several specifications of this variable were tested to determine the best fit for the overall model:

- Lake Keowee elevation in feet above MSL (with MSL normalized to 100 feet)
- Number of feet BFP
- Lake elevation less minimum elevation during period,
- Lake elevation less mean elevation during period.

Ultimately, the Keowee level measurement was chosen as the best fit to model changing water levels on housing values.

Table 15: Hedonic Summary Statistics: Pickens County

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
Home Attributes					
Acres	6839	1.280	3.700	0	96.99
Square Feet	6839	1524.067	510.256	1	5482
Bedrooms	6839	2.864	0.627	0	7.000
Baths	6839	1.760	0.694	0	7.000
Sale Price	6839	140156.332	166889.082	0	3354085
Discount Sale Price	6839	153905.414	175864.912	0	3416894.56
Actual Value	6839	185768.394	260446.911	0	3857100
Census Block Characteristics					
Population	6839	5122.965	1952.148	982	9978
Same_House	6839	4284.934	1717.859	907	9177
Same_County	6839	438.089	275.809	18	1284
Different_County	6839	179.964	215.293	0	2343
Different_State	6839	144.843	139.861	9	1170
Abroad	6839	13.087	25.099	0	116
School Enrollment	6839	1416.133	938.196	208	6802
Enrolled Preschool	6839	64.012	47.761	0	190
Enrolled Kindergarten	6839	76.998	59.835	0	253
Enrolled Grades 1-4	6839	271.247	130.074	0	470
Enrolled Grades 5-8	6839	284.243	162.909	0	782
Enrolled Grades 9-12	6839	249.665	103.432	0	427
Enrolled College	6839	377.049	669.253	17	6773
Enrolled Graduate	6839	92.919	183.858	0	987
Male BS Degree	6839	248.123	164.726	12	586
Male MA Degree	6839	101.721	112.704	6	508
Male Prof Degree	6839	18.607	16.372	0	61
Male PhD	6839	33.669	59.609	0	230
Female BS Degree	6839	224.731	135.308	12	532
Female MA Degree	6839	115.356	101.246	0	415
Female Prof Degree	6839	13.416	11.840	0	42
Female PhD	6839	16.985	26.979	0	86
Median HHI	6839	44131.873	9488.069	11538	62907
Median Year Built	6839	1981.115	7.466	1963	1991
Median Home Vale	6839	122310.557	26851.634	73600	174500
Lake Related Attributes					
Keowee Level	6779	96.605	1.782	92.99	99.65
Average Temperature	6780	63.041	12.866	35.8	84.7
Hartwell Level	6839	655.256	4.731	638.99	662.63

Table 16: Hedonic Summary Statistics: Oconee County

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
Home Attributes					
Acres	1631	0.810	1.039	0.013	24.840
Floors	1631	1.332	0.508	0.000	3.000
Total Rooms	1631	2.299	3.592	0.000	15.000
Bedrooms	1631	1.782	36.955	0.000	1492.000
Bathrooms	1631	1.595	38.039	0.000	1536.000
Total Living Area	1631	2531.904	1225.810	0.000	15848.000
Basement	1631	1596.433	921.884	0.000	5107.000
Distance to Seneca	1580	16.019	6.315	2.193	31.773
Sales Price	1631	426510.497	530629.544	25000.000	4345906.000
Discount Sale Price	1631	474383.689	546068.582	32054.707	4439136.750
Census Block Characteristics					
Population	1631	6241.550	916.747	4207.000	7645.000
Same_House	1631	5506.168	620.519	3836.000	6399.000
Same_County	1631	320.341	98.895	219.000	472.000
Different_County	1631	165.984	113.752	13.000	323.000
Different_State	1631	190.093	156.933	29.000	452.000
Abroad	1631	23.231	28.504	0.000	71.000
School Enrollment	1631	1318.207	360.002	821.000	1597.000
Enrolled Preschool	1631	78.018	34.228	45.000	134.000
Enrolled Kindergarten	1631	54.551	12.279	39.000	94.000
Enrolled Grades 1-4	1631	240.554	76.976	133.000	405.000
Enrolled Grades 5-8	1631	302.012	54.227	235.000	371.000
Enrolled Grades 9-12	1631	348.855	139.787	188.000	522.000
Enrolled College	1631	258.955	146.666	96.000	484.000
Enrolled Graduate	1631	35.262	18.039	15.000	70.000
Male BS Degree	1631	466.247	192.355	195.000	680.000
Male MA Degree	1631	148.391	63.764	46.000	247.000
Male Prof Degree	1631	83.641	25.042	42.000	113.000
Male PhD	1631	68.134	61.904	0.000	165.000
Female BS Degree	1631	331.438	170.433	127.000	551.000
Female MA Degree	1631	276.711	116.855	55.000	467.000
Female ProfDegree	1631	33.151	7.293	0.000	46.000
Female PhD	1631	15.294	12.000	0.000	28.000
Median HHI	1631	51045.589	2474.893	41378.000	53359.000
Median Year Built	1631	1985.414	2.848	1976.000	1989.000
Median Home Value	1631	184742.060	39810.513	100400.000	238400.000
% Change in Per Cap Inc	1488	3.796	1.750	0.000	7.100
Lake Related Attributes					
Hartwell Level	1631	656.086	4.717	638.990	662.630
Average Temperature	1631	65.606	13.310	39.800	98.810
Keowee Level	1631	96.905	1.821	93.101	99.645

Model One: Pickens County

Initial model testing indicated the need for polynomial transformations of the Lake Keowee water level variable. Model testing revealed the significance of a quadratic relationship between water level and the log of home sales price.

Figure 5 illustrates that there are a minimum of three distinct ranges where the relationship between water level and home sales price change. Upon visual inspection, up through a level of 94 feet, as the water level declines home sales prices appear to increase. There are several additional water level ranges that reveal this potentially counter-intuitive finding. Further testing of this relationship in a full hedonic model provides additional insight into the variables that influence home sale prices in Pickens County. Moreover, this graphical presentation confirms testing the lake elevation variable as a polynomial for Pickens County.

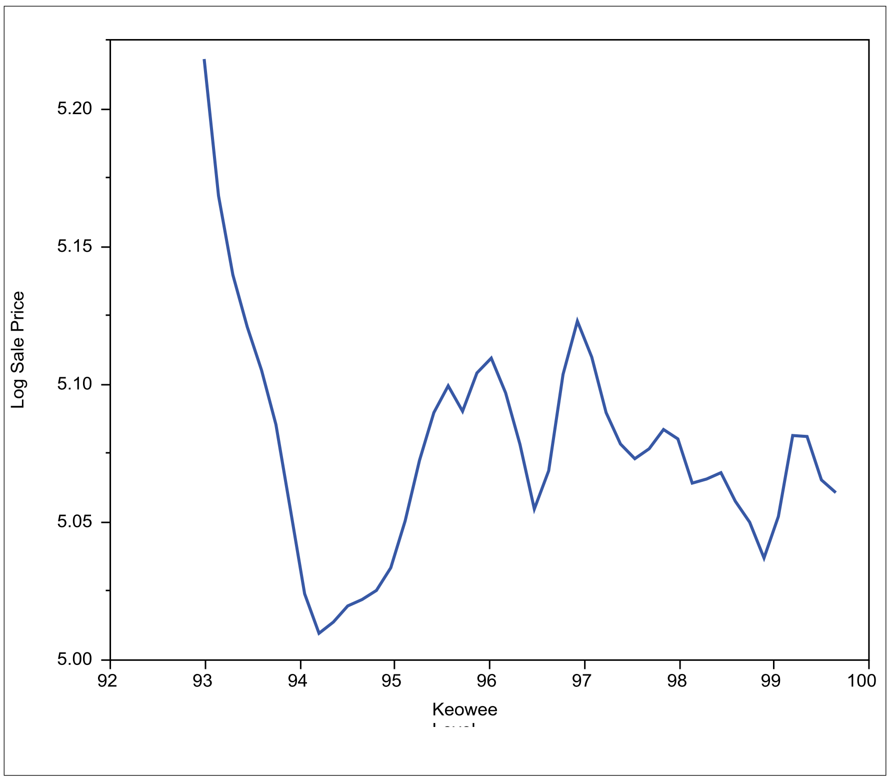

Figure 5: Log Sale Price\ Pickens County vs. Water Level

Full hedonic model results for Pickens County are provided in Tables 17 and 18. Individual county models were chosen because the data across counties was too inconsistent to create a pooled sample. Equally important, a critical assumption of hedonic modeling is homogeneous regions. Thus, individual county models meet this assumption with a higher degree of homogeneity.

Overall model results indicate that this analysis contributes to our understanding of the factors that influence housing prices in Pickens County. The adjusted R-square for Pickens County is 0.28003952. This reveals that 28 percent of the variation in Pickens County housing prices can be explained by this set of variables. The global F-statistic also indicates that the overall model is a significant.

Table 17: Model Summary: Pickens County

Summary of Fit	
R-square	0.282589
Adjusted R-square	0.280039
Observations (or Sum Wgts)	6778
Prob > F	<.0001
Total Error	462.33519

Model results for structural and census block characteristics reveal statistical significance and expected signs. The number of bedrooms, bathrooms and square footage are all statistically significant with an expected positive coefficient. Neighborhood characteristics in both models are important for further clarifying indicators of housing sales price.

For the Pickens County model, all census block education variables were significant and most revealed positive coefficients. However, the number of children in preschool, grades 5-8, and the number of females with professional degrees all had negative signs. Some research indicates that close proximity to middle and high schools does not result in an increase in housing sales price. Moreover, many of these neighborhoods attract semi-retired and retired individuals and communities with significant populations of toddlers and middle school age children may not be attractive to these buyers. The coefficient on the number of females with professional degrees is likely negative because there are so few observations within each census block. Census block data on median year built, median home value, and median household income all reveal expected signs and are statistically significant.

The lake elevation measures—Lake Keowee water level, level squared, cubed, quadratic, and Hartwell Lake interactions—are all statistically significant, which is evidence that there is a relationship between lake elevation and housing sales price. However, as Figure 5 illustrates, the relationship is more complex than hypothesized and not easily predictable.

To predict the impact of Lake Keowee elevation on sales price, the partial derivative of elevation was taken and models were estimated using different Lake Keowee and Hartwell Lake elevations. A distribution of Lake Keowee elevations during the study period was divided into quartiles (Table 19). Elevations at the 25 percent quartile (94.99 feet, MSL normalized to 100 feet), 50 percent quartile (96.15 feet) and 75 percent quartile (98.33 feet) were used for model estimations. The elevation used for Hartwell Lake in all models was its average level over the period, 655.3 feet above MSL.

Table 18: Parameter Estimates: Pickens County

Parameter Estimates			
Term	Estimate	t Ratio	Prob>|t|
Intercept	152951.79	4.54	<.0001***
Home Attributes			
Acres	0.0079851	8.97	<.0001***
Square Feet	0.0001287	14.97	<.0001***
Bedrooms	0.0331275	5.03	<.0001***
Baths	0.0826405	12.45	<.0001***
Sale Date	4.70E-10	10.07	<.0001***
Census Block Characteristics			
Same County	-9.66E-05	-3.78	0.0002**
Preschool Enrollment	-0.001054	-7.04	<.0001***
Kindergarten Enrollment	0.00119	11.29	<.0001***
Grade 1-4 Enrollment	0.0003332	6.32	<.0001***
Grade 5-8 Enrollment	-0.000656	-12.09	<.0001***
Male BS Degree	0.0003839	8.52	<.0001***
Male ProfDegree	0.0019899	6.78	<.0001***
Male PhD	0.0011931	6.93	<.0001***
Fem ProfDegree	-0.002116	-4.45	<.0001***
Median YR Built	0.0023773	3.55	0.0004**
Median Home Value	-1.74E-06	-5.71	<.0001***
MedHHI	3.15E-06	3.69	0.0002**
Lake Related Attributes			
Keowee Level	-6281.291	-4.48	<.0001***
Hartwell Level	-4.974468	-1.72	0.085*
Keowee^2	97.061607	4.44	<.0001***
Keowee^3	-0.668898	-4.42	<.0001***
Keowee^4	0.0017346	4.42	<.0001***
Keowee Level*Hartwell Level	0.1028854	1.72	0.0859*
Keowee2*Hartwell Level	-0.000532	-1.71	0.0869*

***t significant at p< .001
**t significant at p< .01
* t significant at p< .05

Table 19: Lake Keowee Elevation Quartiles

Quartile	Description	Elevation (in feet above MSL)*
100.00%	maximum	99.65
75.00%	quartile	98.33
50.00%	median	96.15
25.00%	quartile	94.99
0.00%	minimum	92.99
Mean		**96.61**

* MSL normalized to 100 feet.

Table 20 illustrates the effect of these three different Lake Keowee elevations on home sale prices when Hartwell Lake is at its average level of 655.3 feet above MSL. When Lake Keowee is at relatively low at the 25 percent quartile (94.99 feet), a one foot decline in the lake's water level results in an approximately 1.6 percent decline in home sale prices. When the lake is at the median (96.15 feet), the impact on sales price is much smaller, less than one-half of one percent.

But the relationship between housing sales price and water level is negative both when the lake gets closer to full pool and to its very lowest levels (below 94.0 feet). This relationship maybe reflective of individuals selling properties more often at low lake levels, which also correspond to summer months when more people have their homes on the market. It may also reflect a "fire sale" mentality whereby people selling homes when levels are lower attempt to sell their homes as quickly as possible before buyers can respond negatively to low lake levels.

Overall, this analysis confirms earlier research that there is a small but statistically significant relationship between water level and housing values. It further confirms that this relationship is considerably more complex than hypotheses might suggest.

Table 20: Marginal Impact of Lake Keowee Elevations on

Pickens County	25%Quartile (94.99 ft)	50% Quartile (96.15 ft)	75% Quartile (98.33 ft)
Sale Price Change	0.0160371	0.00050809	-0.01784811
+/- Standard Error	0.0087327	0.00642786	0.00924719
Hartwell Lake Elevation	**655.3 ft**	**655.3 ft**	**655.3 ft**

Model One: Oconee County

Initial model testing for Oconee County indicated the need for polynomial transformations of the Keowee elevation variable. Model testing revealed the significance of a cubic relationship between water level and log of home sales price.

Figure 6 illustrates that there are a minimum of three distinct ranges, where the relationship between water level and sales price change. Upon visual inspection, up through a lake elevation of approximately 94.6 feet, sales price appears to increase as water level declines. There are several additional lake elevation ranges that reveal this potentially counter-intuitive finding. Further testing of this relationship in a hedonic model provides additional insight into the factors that influence home sales prices in Oconee County. The graphical presentation confirms our decision to test the lake elevation variable as a polynomial for Oconee County.

Model results for Oconee County are provided in Tables 21 and 22. Overall model results indicate that this analysis contributes to our understanding of the variables that influence housing prices in Oconee County. The adjusted R-squared for Oconee County is 0.21031, or 21 percent of the variation in Oconee County housing prices can be explained by this set of variables. The F-statistic also indicates that the overall model is statistically significant and different than zero.

Table 21: Model Summary: Water Level and Oconee County

Summary of Fit	
R-square	0.216152
Adjusted R-square	0.21031
F Ratio	37.0016
Number of Observations	1488

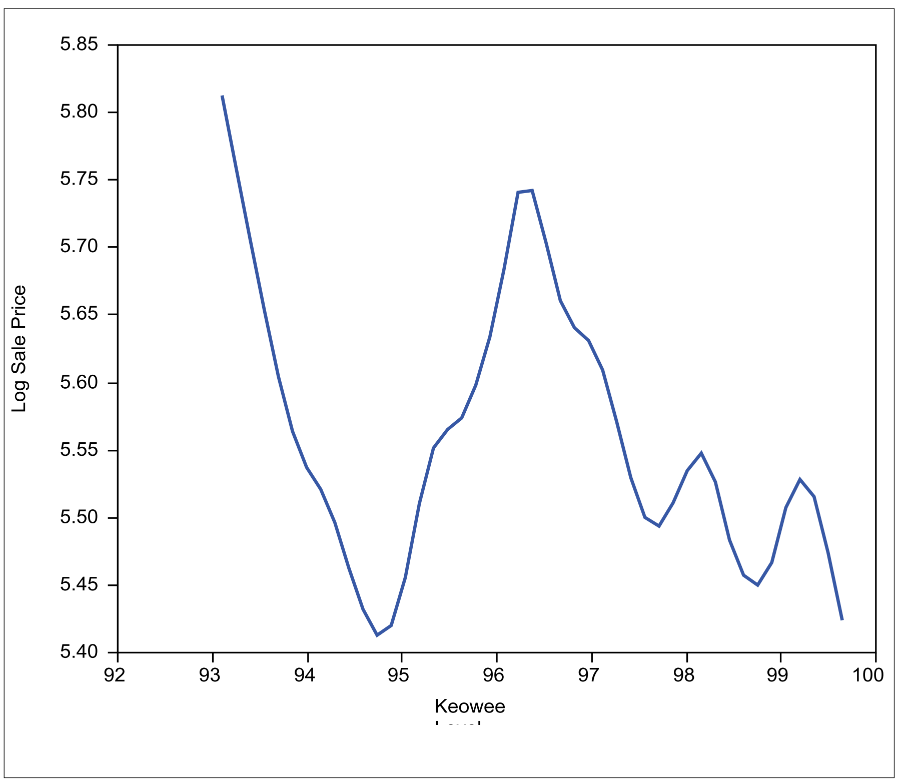

Figure 6: Log Sale Price\ Oconee County vs. Water Level

Model results for Oconee County were significant across fewer structural and census block characteristics than in Pickens County. We attribute this to two primary factors: 1) this analysis only includes lakefront parcels and transactions, as opposed to data covering the entire county; and 2) the data from Oconee County's tax files are not comprehensive in reporting structural characteristics across properties and thereby may yield unreliable estimates across the sample.

Nevertheless, the number of bedrooms and total living area are both statistically significant with an expected positive coefficient. None of the census block variables were statistically significant for Oconee County. However, the indicator representing distance of less than half a mile to the nearest golf course was statistically significant with a negative coefficient. Average temperature was significant with a negative coefficient. County per capita income was significant with a positive coefficient.

The lake elevation measures—Lake Keowee water level, level squared, cubed, quadratic, and an interaction with average temperature—are all statistically significant, which is evidence that there is a relationship between lake elevation and housing sales price. As with Pickens County, this relationship is more complex than hypothesized and not easily predictable.

To predict the impact of Lake Keowee elevation on sales price, the partial derivative of elevation was taken and models were estimated using different Lake Keowee elevations and average temperatures. The same distribution of elevations used to estimate the Pickens County results were used for Oconee County: 25 percent quartile (94.99 feet, MSL normalized to 100 feet), 50 percent quartile (96.15 feet) and 75 percent quartile (98.33 feet).

Table 22: Parameter Estimates: Oconee County

Term	Estimate	t Ratio	Prob>|t|
Intercept	4253.056	2.43	0.015*
Month Index	0.004895	12.29	<.0001***
Beds	0.000562	2.77	0.0057**
Total Living Area	0.00001	1.56	0.1198
Golf1	-0.09432	-2.89	0.0039**
Sale Date	-3.19E-10	-4.02	<.0001***
Average Temperature	-0.07803	-1.87	0.0615
Per Capita Income	0.010825	2.24	0.0254*
keo_level	-1.33E+02	-2.44	0.0147*
keowee^2	1.378651	2.45	0.0142*
keowee^3	-4.78E-03	-2.47	0.0137*
Keowee Level * Avg. Temp.	0.000835	1.94	0.053*

***t significant at p< .001
**t significant at p< .01
* t significant at p< .05

Table 23 illustrates the sales price impact at these three lake levels assumed average temperatures of 35.8, 63.04, and 84.7 degrees Fahrenheit. When Lake Keowee is at relatively low at the 25 percent quartile (94.99 feet), a one foot decline in the lake's water level results in an approximately 1.5 percent decline in home sale prices. When the lake is at the median (96.15 feet), the negative impact on sales price is larger at 3.3 percent.

But as seen in Pickens County, the relationship between housing sales price and water level is negative both when the lake gets closer to full pool and to its very lowest levels (below 94.6 feet). This relationship maybe reflective of individuals selling properties more often at low lake levels, which also correspond to summer months when more people have their homes on the market. It may also reflect a "fire sale" mentality whereby people selling homes when levels are lower attempt to sell their homes as quickly as possible before buyers can respond negatively to low lake levels.

Overall, this analysis confirms earlier research that there is a small but statistically significant relationship between water level and housing values. It further confirms that this relationship is considerably more complex than hypotheses might suggest.

Table 23: Marginal Impact of Lake Keowee Elevations on

T= 63.04° (F)	25%Quartile (94.99 ft)	50% Quartile (96.15 ft)	75% Quartile (98.33 ft)
Sale Price Change	0.015232496	0.033287067	-0.0372453
+/- Standard Error	0.01506421	0.010474423	0.01542899
t Ratio	1.011171193	3.177937941	-2.41398169
Prob>|t|	0.312100231	0.001514009	0.01590031
T= 35.8 ° (F)			
Sale Price Change	-0.00748679	0.010567782	-0.059964584
+/- Standard Error	0.015206769	0.01369612	0.022853394
t Ratio	-0.49233272	0.771589494	-2.623880898
Prob>|t|	0.622557373	0.440481108	0.008783051
T= 84.7° (F)			
Sale Price Change	0.033357808	0.05141238	-0.019119986
+/- Standard Error	0.02051609	0.015652843	0.014447279
t Ratio	1.625934011	3.284539379	-1.323431644
Prob>|t|	0.104177165	0.00104543	0.185896828

Housing Prices: Summary

The statistical significance of the lake elevation leads us to question the rational assumptions that buyers and sellers make when considering lake purchases. Water level changes are almost always temporal events. Even in record drought years, it is generally assumed that at some point the drought will be over. If consumers understand and internalize this knowledge, water level would not be significantly correlated with sales price.

Given these results, are consumers and homeowners behaving irrationally in their capitalization of lake level? Research on negative environmental characteristics indicates that consumer's physical view of the lake and their perceptions of current and future events also influence the capitalization of these different characteristics. Understanding how buyers and sellers conceptualize this characteristic is an important area for additional research. Survey research, in addition to hedonic models, could provide additional insight into consumer perceptions.

Overall, this analysis begins to provide evidence of the relationship between lake level and home sales prices. However, several limitations remain. The current model only examines data on lakefront properties in Oconee County. A data set including the entire county's real estate transactions over the time period (as was used for the Pickens County model) would provide a more complete picture of the value of these characteristics in this housing market. As well, additional lakefront characteristics, like length of shoreline, cove versus full water lake access, slope of lakefront, among others would provide additional understanding of the value of the lake as a housing amenity.

As the number of lake related stakeholders continues to grow, these are questions that will remain important for consumers, businesses and policymakers. Overall, this research provides initial insight into the relationship between lake level and sales price. Moreover, this analysis confirms that these variables do not have a simple linear relationship and that future research would benefit from further exploration of model specification.

VIII. Application to Flow Simulation Models

The purpose of the preceding analysis is to provide an estimate of the economic impacts that alternative water release arrangements between Duke Energy and USACE would have on the two counties bordering Lake Keowee as well as the six South Carolina and Georgia counties bordering Hartwell Lake. HDR Engineering provided Duke Energy with simulations for three alternative flow scenarios regarding releases from Lake Keowee into Lake Hartwell through the Keowee Dam. These simulations estimate the elevation of the two lakes under each scenario relative to a baseline.

The project team applied the estimated economic, fiscal, and property values impacts to the HDR simulations by first differencing the two lakes' elevation predicted by each alternative scenario from the baseline elevation. This difference was then multiplied by the estimated marginal (per-foot) impact on a county-by-county basis.

Impact estimates for Lake Hartwell included impacts on gross retail sales and lake-adjacent real estate transactions for the six counties bordering Lake Hartwell: Anderson, Oconee, and Pickens Counties in South Carolina, and Franklin, Hart, and Stephens Counties in Georgia. Impact estimates for the Lake Hartwell counties were obtained from a 2010 study conducted by STI for USACE (Allen et al, 2010). Impact estimates for Lake Keowee included impacts on gross retail sales and lake-adjacent real estate transactions, as well as impacts on property values for lake-adjacent properties. (No property values models were available for the 2010 Hartwell study.)

By way of example, the HDR simulation provided a baseline elevation on January 1, 2001 of 793.77 feet MSL for Keowee and 651.84 feet MSL for Hartwell. Under one alternative release scenario, HDR estimated Lake Keowee's elevation would have been 794.72 feet MSL on that date, and Hartwell Lake's elevation would have been 651.87 feet MSL. This works out to a difference in elevation of 0.95 feet from the baseline for Lake Keowee and 0.03 feet from the baseline for Hartwell Lake.

Under this same release scenario, the impact on output per day for Oconee County from a one-foot change in Lake Keowee elevation is approximately +$6,700; therefore, the estimated impact from the 0.95 foot change in elevation under the alternative scenario is +$6,459. The estimated impact on daily output from a one-foot increase in elevation in Hartwell Lake from the baseline elevation is about

-$6,800; the impact from the 0.03 foot change in elevation under the alternative scenario is approximately -$230 (figures are rounded). These impacts can be summed over time to indicate a cumulative estimated economic impact from prolonged changes in lake elevation.

The same methodology was used to apply the hedonic (property values) impact estimates to the HDR simulations for Lake Keowee. [6] Again, using Oconee County as an example, the change in property value, as measured by sale price, from a one-foot drop in Keowee elevation from HDR's baseline level of 793.77 feet MSL is approximately 1.5 percent of the property's value. The median sale price of a Keowee lakefront parcel in Oconee in 2001 was $266,668 (in 2010 dollars). Therefore, for the 0.95 foot change in elevation estimated by this flow scenario, the estimated impact on property value from the modeled change in elevation for a given parcel sold

[6] Hedonic models were not included in the Hartwell study.

on that day would be +$3,879. These impacts can be multiplied by the number of lakefront parcels in each county (see Table 1) in order to estimate the potential impact on property values from a given change in lake elevation. This impact is potential, because it would only be realized if parcels were sold at the time that Lake Keowee was at each projected level.

VIII. CONCLUSION

This study was designed to estimate the amount by which changes in the elevation of Lake Keowee affect county-level (or regional) economic activity. The economic impact of lake elevation was primarily evaluated in three ways:

- impact on gross retail sales of lake-related enterprises,
- impact on lakefront real estate sales, and
- impact on the value of lakefront property.

Our findings indicate that changes in volume of real estate sales and the value of gross retail sales have comparable effects on the economy of the two counties. Lake Keowee's elevation has a larger dollar impact on gross retail sales in Pickens County than in Oconee County. But lake elevation has a larger impact on the economic impact of real estate sales in Oconee County than in Pickens County. This is somewhat to be expected, given the large historical emphasis on real estate on the Oconee County shores of the lake, with large developments such as Keowee Key and others. While lakefront real estate has gained a larger presence in Pickens County, this has been more recent relative to Oconee County. The retail impact in Oconee County, however, is still large relative to that in Pickens County, likely due to the proximity of commercial activities in and around the town of Seneca to the lake.

Our economic impact analysis shows that low water levels in Lake Keowee adversely affect the economies of both counties, although those impacts—while statistically significant—are not large relative to the overall economy of these counties. These results indicate that the overall economic impacts due to changing lake levels are very small in relation to overall regional economic activity.

The economy of Upstate South Carolina, while historically dependent on agriculture and textiles, is now relatively diverse; so no single factor is the primary driver of economic activity. While tourism and lake related recreation activity is an important contributor to economic activity, residents should consider lake recreation and tourism as one piece in their overall basket of economic growth and development options. South Carolina communities have, unfortunately, been witness to what happens when local economies are closely, or exclusively, tied to a specific sector, such as the demise of the textile industry. Regional breadth and depth of economic activity is the objective for sustainable growth and development.

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