**SS-AAEA Journal of Agricultural Economics**

*Determinants of Residential Water Pricing in the Metro Atlanta Region*

By Travis A. Voyles

---


***Abstract***

*Water scarcity is one of the greatest growing social and economic concerns for many regions around the world. The State of Georgia has experienced these concerns first-hand within the metro Atlanta region and the Chattahoochee River basin. The residential consumers of the water supplied by the local water systems have endured this water crisis with their own livelihoods depending on the supply of the water resource. The way the individual water systems have handled the growth and security problems differently by adopting different programs and systems has created different costs to each water system. Higher prices for the water resource result in a higher bill for the residential consumers. Understanding and analyzing the variation in the different variables chosen help to determine what factors lead to changes in pricing for the used water resource. The population, income and educational program variable were found to have the largest influence on the used regression equations. These variables agree with most economic theory and social expectations. The most significant finding was the great significance the educational program variable was found to represent, describing a situation where a more social aspect variable of the regression model was found to be the most influential.*


All across the globe water scarcity has become an increasing social and economic concern for public administrations and competing water users (Varela-Ortega). Water scarcity in the state of Georgia is known to be one of the largest challenges that will have to be continually faced going into its future. Specifically, the metro Atlanta region has experienced growth in the past two decades that have put the region at the center of a water crisis. The metro Atlanta region is home to more than 4 million people and it is also one of the fastest growing metropolitan areas in the nation. The metro Atlanta region relies very heavily on the Chattahoochee River and its tributaries for a majority of its water supply source, but the Chattahoochee River Basin is one of the smallest river basins in the state of Georgia. The Chattahoochee River is developed with a number of dams including the Buford Dam which forms Lake Lanier. Lake Lanier is owned, operated and managed by the United States Army Corps of Engineers (COE) which has the primary voice in water control management projects (Erhardt).

Recent events dealing with the Chattahoochee River and Lake Lanier have complicated water scarcity problems even further for the parts of the metro Atlanta region that rely on the Chattahoochee River and its watershed for their water supply. In July of 2009, United States District Court Judge Paul Magnuson determined that the only authorized purposes of Lake Lanier are hydropower, flood control, and navigation, which were the reasons of its initial construction. This comes into collision with the actions of the COE which have been since 1986 allowing contracts to be formed with local municipalities increasing their water withdrawals from Lake Lanier (Erhardt). The City of Atlanta and other cities in the metro Atlanta area that relied on the lake for their water source have been given a window of three years to change their ways or obtain approval from Congress to allow the water withdrawals to still be used for water supply purposes. Mediation talks between the three states of Georgia, Alabama and Florida, who are all involved in the case, have not been as productive as hoped and present an unknown future for the use of Lake Lanier as a municipal water supply source.

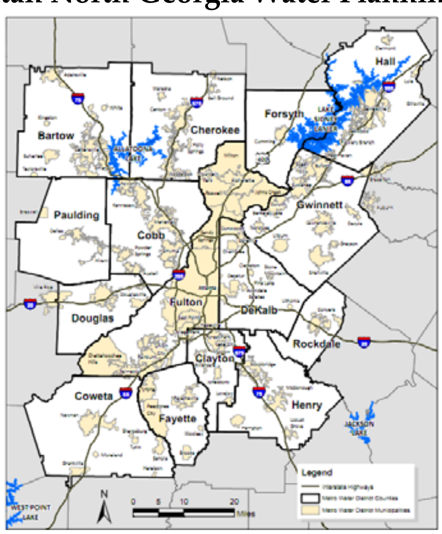
The residential sector of the metro Atlanta region has endured this water crisis first hand as their way of life depends on the security of the water resource supply and the factors that come along with it. All across the region water systems have handled the growth and security problems differently by adopting different programs and systems to manage their water supply.

The research is aiming to find determinants of what influences water pricing differences for the water systems around the metro Atlanta region. Understanding and analyzing the variation in the different variables chosen will help determine what factors lead to changes in pricing for the used water resources. Factors affecting water pricing directly influence the residential sector of the metro Atlanta area. Higher prices for the water resource result in a higher bill for the residential consumers. The continued debate over the future water security for the metro Atlanta region creates that described situation and results in a greater cost for the consumers. Policy makers could utilize the results of this analysis to encourage changes in certain areas of individual water systems that could possibly result in a decrease in prices for their residential consumers through the use of better policies and actions.

### Introduction to Water Pricing in the Metro Atlanta Region

The metro Atlanta region contains the fifteen counties of Bartow, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Hall, Henry, Paulding and Rockdale counties. The water planning authority for the fifteen county metro Atlanta region is the Metropolitan North Georgia Water Planning District (MNGWPD), which is the overall authority for the five water authorities, nine county systems and forty-two municipal systems that provide water to residents within the region (Figure 1). The residential water prices for all water systems are shown in Table 1.

**Figure 1: Metropolitan North Georgia Water Planning Distract (MNGWPD)**




Source: Metropolitan North Georgia Water Planning District. 2011, Activities and Progress Report – 2010.

**Table 1: Residential Water Prices for Metro Atlanta Region Water Systems**

| Water System | 2010 Monthly Residential Water & Wastewater Bill | Water System | 2010 Monthly Residential Water & Wastewater Bill |
|---|---|---|---|
| Bartow County Water Department | 57.8 | Forsyth County Water and Sewer | 68.04 |
| Adairsville | 28.06 | Cumming | 36.78 |
| Adairsville (Outside City Limits) | 42.1 | Cumming (OCL) | 41.38 |
| Cartersville | 32.16 | Fulton County Department of Public Works | 66.36 |
| Cartersville (OCL) | 57.32 | Atlanta Department of Watershed Management | 134.99 |
| Emerson | 58.26 | Atlanta Department of Watershed Management (OCL) | 83.99 |
| Emerson (OCL) | 99.89 | College Park | 71 |
| Kingston | 45 | East Point | 35.25 |
| Kingston (OCL) | 67.5 | Fairburn | 84.46 |
| White | 57.5 | Fairburn (OCL) | 123 |
| White (OCL) | 68 | Hapeville | 75.66 |
| Cherokee County Water and Sewer Authority | 68.2 | Mountain Park | 87.18 |
| Ball Ground | 79.15 | Palmetto | 64.4 |
| Ball Ground (OCL) | 90.15 | Roswell | 70.54 |
| Canton | 62.7 | Union City | 86.56 |
| Waleska | 34.38 | Gwinnett County Department of Water Resources | 69.44 |
| Woodstock | 92.06 | Braselton | 62.86 |
| Clayton County Water Authority | 55.92 | Braselton (OCL) | 69.81 |
| Cobb County Water System | 57.25 | Buford | 10.4 |
| Austell | 53.86 | Buford (OCL) | 18.8 |
| Austell (OCL) | 56.92 | Lawrenceville | 29.46 |
| Marietta Power and Water | 73.98 | Norcross | 77.52 |
| Powder Springs | 59.28 | Suwanee | 64.37 |
| Powder Springs (OCL) | 66.76 | Flowery Branch | 70.63 |
| Smyrna | 73.98 | Flowery Branch (OCL) | 86.28 |
| Coweta County Water and Sewerage Authority | 87.92 | Gainesville | 64.34 |
| Grantville | 79.5 | Gainesville (OCL) | 87.35 |
| Newnan Utilities | 52.95 | Henry County Water and Sewerage Authority | 66.72 |
| Newnan Utilities (OCL) | 67.05 | Henry County Water and Sewerage Authority (Outside County Limits) | 100.08 |
| Senoia | 69.5 | Hampton | 74.02 |
| Turin | 80.54 | Locust Grove | 76.38 |
| DeKalb County Water and Sewer | 59.52 | McDonough | 61.8 |
| Douglasville-Douglas County Water and Sewer Authority | 68.54 | Stockbridge | 70.48 |
| Villa Rica | 61.69 | Paulding County Public Works | 70.96 |
| Villa Rica (OCL) | 92.44 | Dallas | 53.52 |
| Fayette County Water System | 31.4 | Dallas (OCL) | 64.68 |
| Brooks | 62.8 | Hiram | 21.3 |
| Fayetteville | 53.45 | Rockdale County Water Resources | 72.88 |

Source: Metropolitan North Georgia Water Planning District. 2011. Water Metrics Report – January 2011.

The objective of this research is to explain water pricing in the fifteen county area that is considered metro Atlanta. Specifically, the goal is to discern determinants of water pricing and to what extent these factors influence the pricing of residential water use in the metro Atlanta region. The variables that were selected represent different factors of the water resource from location, amount and handling that could play a large role in the final price that is charged to consumers. The data yielded from the results of the regression analysis will hopefully allow for accurate predictions about residential water pricing.

## Theoretical Framework

Population growth of the area that the water system serves certainly impacts the price of the water that is provided to consumers. The greater the numbers of people being served by the water systems, the larger the amount of water they must be able to handle which will require a larger and more technical distribution system. These are all costs that the water system has to incur and in most situations will be reflected in the price of the good they provide which in this case is the water supply to the consumers (Brill). Basically, as the population served by the water system rises it should have a positive effect on the pricing of the water. This is also the case with the variable of the average gallons per day that a single family uses in the winter season. As this number increases in the models it would relate to the water systems having to supply a greater amount of water to the consumers. This increase in supply would also incur costs for the supplying water system regardless of the size of the residential population. Whether the population is small or large increased use per day by consumers would be hypothesized to cause an increase in water prices for the system.

The change in population of the area of the water system over the last ten years from 2000 to 2010 shows the growth and change of the supply dynamic for the individual water systems. Those water systems with high population changes in many cases have had to undergo changes and additions to their systems to be able to handle the increase. Costs associated with these changes could play a major role in the determining of water pricing for the water systems. Many of the costs are the result of enlarging a water system's capacity or breadth, which are major and expensive undertakings. Overall, as the population change increases, it would have a positive impact on the pricing of the water resource.

Income elasticity is a basic economic principal that can be applied when analyzing the pricing of water. Income elasticity is the change in an individual's demand for a good when they undergo a change in income (Perloff). This change in demand can have a direct positive effect on the price if more water is demanded by a rise in the individual's income. This classifies water as a normal good since the characteristic of a normal good is the demand for that good will increase as their income increases. Overall, it can be hypothesized that as income increases, the demand curves will shift positively which will ultimately cause a rise in prices.

Scarcity is a basic economic principal describing a situation where there are unlimited needs and wants of a limited resource (Perloff). Water in the Chattahoochee River Basin is a scarce resource due to the ever-growing population of the metro Atlanta region that has become reliant on the water for their daily lives. With the presence of such tremendous scarcity in the river basin the water prices would reflect that scarcity by increasing. Withdrawal of a water system's water source from within the Chattahoochee River Basin would also have a positive impact on the resulting price of the water resource when it is supplied to the consumers.

Consumer and producer knowledge about the good can also impact the final condition of the good, as in this case with the price of the bill that the consumers receive. The education program variable indicates whether or not the water system provides a conservation education and public awareness program to its consumers. These types of programs could result in greater consumer knowledge about the water they consume and result in changes in their behavior which is hypothesized to have a negative impact on pricing. The pricing structures that are present in different water systems are due to an increase in knowledge by the water system as a producer of the water resource that is sold. The tiered structures that are present allow for different amounts to be charged for different quantities of water used. The most popular of the structures is an increasing block structure, where as the water usage increases the price also increases according to the different ranges the consumption level falls within.

**Table 2: Hypothetical Relationship between Residential Water Prices and Variables**

| Variable | Hypothesis |
|---|---|
| Population | Positive |
| Population Change | Positive |
| GPD | Positive |
| Income | Positive |
| Ed. Program | Negative |
| Source | Positive |
| Blocks | Negative |

## Methodology

The hypothesized regression model examines factors associated with residential water pricing in the metro Atlanta region. Data was compiled for fifty-seven water systems that are present in the metro Atlanta region and then used in the regression analysis. Nineteen of the fifty-seven water systems had different billing data whether they were inside or outside city limits so they were split into two separate systems with all the other variables staying constant, which resulted in a total of seventy-six water systems used.

The dependent variable in the regression analysis is the 2010 monthly residential water and wastewater combined bill, which was compiled by the Metropolitan North Georgia Water Planning District in their annual Water and Wastewater Rate Survey. The monthly combined bill assumes that that an average household uses 6,000 gallons of water each month and the price of the bill that is given is a reflection of that estimate multiplied by the rate of the corresponding water authority or municipality. The first independent variable used in this model is the population that each of the seventy-six water systems serves according to the 2010 Metro Water District Plan Implementation Review provided by the MNGWPD. The next independent variable, which was obtained from the 2010 Census, is the population change of each water system from 2000 to 2010 expressed as a percentage. The third independent variable used was average gallons per day that a single family uses over a winter month which was obtained from the MNGWPD 2010 Metro Water District Plan Implementation Review. Since the data values for the systems within the same county were very similar, an average value for the water system's county was used if the data was not present in the review. The fourth independent variable used in the regression analysis was the per capita income in 2008 in dollars for the county where the individual water system is located. Data was obtained for the fifteen counties from the Georgia Statistics System county-by-county analysis access base. The fifth independent variable was a dummy variable and represented whether or not there was a conservation education and public awareness program provided by the water system where 1 equals a program present and zero equals a lack of a program present and was obtained from the MNGWPD 2010 Metro Water District Plan Implementation Review. The sixth independent variable is also a dummy variable representing the water withdrawal source. In this situation a one represents the water source is withdrawing its water from the Chattahoochee River watershed and a zero represents water withdrawal from another river watershed in the area. The final independent variable for the regression analysis is the number of pricing blocks that are present in the water system's pricing structure. Most systems used an increasing block pricing structure and the number represents the quantity of tiers or blocks that are in place with one representing the lack of an increasing block structure or a flat uniform rate.

Four different types of linear regression functional forms were found in this model using the SAS software which assists in determining the best-fit model for the given data. The regressions used initially were the linear, log-log, log-linear, and the linear-log forms. Using the different derived models a best model was determined using certain criteria. The model with the β coefficients that have expected signs, reasonable magnitudes and are Best Linear Unbiased Estimators (B.L.U.E.) along with high t-statistics and high R-squared values are determined to be the best fit (Hill). The liner functional form was used ultimately for the regression analysis. In all of the functional forms the R2 value and t-statistic values were very similar. The linear model had a slightly higher R2 value of .2406, which indicated that 24.06% of the dependent variable's variation could be explained by the linear regression model. The log-log and linear-log models had negative β intercepts which is unrealistic when dealing with pricing. The main factor that set the linear functional form apart from the others was the presence of reasonable magnitudes for the β coefficients and the β's for population, population change, income and education program that meet a 95% significance level. The regression equation for this econometric model in linear form is:

$$y = \beta_1(population) + \beta_2(population\ change) + \beta_3(GDP) + \beta_4(income) + \beta_5(educational\ program) + \beta_6(source) + \beta_7(blocks)$$

## Empirical Results

The following table shows the regression analysis data that was derived from the linear functional form and used in the equation:

**Table 3: Parameter Estimates for Coefficient Values for Residential Water Pricing**

| Variable | Coefficient Value | Standard Error | t Value |
|---|---|---|---|
| Population | 0.00004623 | 0.00001648 | 2.81 |
| Population Change | 8.60711 | 3.45625 | 2.49 |
| GPD | -0.13632 | 0.14928 | -0.91 |
| Income | 0.00067789 | 0.00033518 | 2.02 |
| Ed. Program | -10.99505 | 5.29519 | -2.08 |
| Source | -1.54808 | 5.70429 | -0.27 |
| Blocks | 0.17452 | 2.72552 | 0.06 |

The primary goal of this analysis was to determine the effects of the independent variables on the dependent variable. One of the initial steps to determine the relationship between the individual variables and the dependent variable is performing a T-test. By choosing the variables that were initially thought to be significant a T-test was performed on each one of them to see if they had a significant influence on the dependent variable. Using economic theory for the variables of population, population change, income, and education program a hypothesis was generated and the results showed that the population, population change and income variable all had a significant positive relationship with the dependent variable. The education program variable was also found to have a significant relationship with the dependent variable but instead of being positive, the variable had a negative relationship with the dependent variable.

To check for problems relating to collinearity existing in the model, the Variance Inflation Factors (VIF) for the variables as well as the Condition Index (CI) must be derived and analyzed in the SAS output. A VIF greater than 10 is a signal that there could be problems with collinearity in the model. Also, if the CI is greater than 100 then there is also a potential problem with the collinearity. If both of the limits are surpassed by the results of the regression then the model has problems with collinearity (Hill). For the linear regression model used in this analysis, the highest VIF value was 1.59 describing the income variable and the highest CI value was 19.74 in relation to the blocks variable. If there had been problems with collinearity a variable with some of the high values could have been dropped. Biasedness could be present if the variable had been left in and caused the analysis to be inaccurate.

Another test that can be performed on the model is the Ramsey Error Specification and Estimation Test or the RESET test. The RESET test tests for misspecification, which can include the wrong functional form being used or inclusion of important omitted variables. Unrestricted and restricted regression models are necessary for the RESET test. The unrestricted model includes the possible omitted variable while the restricted model is the original linear functional form. This focus on the omitted variable will help determine if the model is well specified. The F statistic value for the model was 0.02054, while the F critical value was much larger at 4.00. This results in an acceptance of the null hypothesis which states that the omitted variable, y2, which was used in the unrestricted model, has zero explanatory power. With the omitted variable having no explanatory power the model has no misspecification occurring.

The model also must be checked for heteroscedasticity by plotting the error terms of the model and continuing on using a Goldfeld-Quandt (G-Q) Test. Plotting allows for a visual detection of heteroscedasticity, which is a violation of the of the least squares assumptions. One statement of the assumptions says that the variance for all observations should be the same or homoscedastic. The plots of the individual variables' observations mostly showed no extreme cases of heteroscedasticity. Only some slight heteroscedasticity in all but the education program and source variable observations was present. The G-Q Test is a type of F-Test that uses the mean square error terms for a variable. Using the plotting of error terms allows a variable to be determined to be used in the test if there is extreme heteroscedasticity present. The population change variable was determined to have displayed the most heteroscedasticity and was used in the G-Q test. Using the mean square errors values of the two divided groups the calculated F statistic vale was found to be 2.4125, and the F critical value was 1.84. Since the F statistic value is greater than the F critical value, the null hypothesis is rejected, indicating homoscedasticity and concluding that there is heteroscedasticity present in the residuals. The following table shows the weighted results producing a Generalized Least Squares model that has been corrected for heteroscedasticity.

**Table 4: Generalized Least Squares Coefficient Estimates for Residential Water Pricing**

| Variable | Coefficient Value | Standard Error | t Value |
|---|---|---|---|
| Population | 0.00003882 | 0.00002019 | 1.92 |
| Population Change | 2.11643 | 1.942 | 1.09 |
| GPD | -0.27471 | 0.1705 | -1.61 |
| Income | 0.00076007 | 0.00036699 | 2.07 |
| Ed. Program | -10.05517 | 4.61158 | -2.18 |
| Source | -0.85478 | 4.7545 | -0.18 |
| Blocks | -1.91124 | 2.87978 | -0.66 |

A final analysis of the regression through an F test can determine the significance of the full model after being weighted for heteroscedasticity. With the f statistic value of 2.39 being greater than the f critical value of 2.25 the null hypothesis of the β's all equaling zero is rejected. A conclusion is deducted from this that the full model has significant explanatory power through the regression equation.

## Discussion of Results

The results of the regression analysis were for the most part expected with the exception of a few instances. The parameter estimates for the independent variables were anticipated for the population, population change, income, education program and blocks variable. The GPD and source variables had opposite signs of the expected values. The gallons per day usage of a single family household would have been thought to have a positive relationship with price of the water resource. Economic theory would suggest that as usage increases the price increases as well. The results suggest differently and show that there may be some relationship in the GPD of water used and the presence of a large water system that is more efficient, therefore resulting in a lower price charged by the system. The source of the water resource was another conflict of expectation. Due to the growth within the metro Atlanta region and the scarcity of the water resources within the river basin economic theory suggests that water systems that have their water withdrawal source within the Chattahoochee River Basin would be at a disadvantage compared to other river basins around the area. This would be expected to have a positive relationship where systems located within the basin would also be associated with increased prices to residential users; however, the results conclude that the opposite is the case in this model.

The ending estimate that shows the population, income and education program variables having the largest influence on the regression equation was expected and agrees with most economic theory and social expectations. The education program variable with its estimate represents the largest level of significance within the model. This finding describes a situation where a more social aspect variable of the regression model was found to be more influential than many of the other popular economic variables.

## Conclusions

The goal of the regression analysis was to examine the determinants of water pricing within the metro Atlanta region due to the growth of the area and continued scarcity of the water resource itself. The regression model compared the monthly residential water and wastewater bill in each of the water systems in the metro Atlanta region to the independent variables: population served in each of those water systems, population change over the past ten years in the areas, average gallons per day of water use for a single family household in the winter season, per capita income in 2008 in the corresponding county, whether or not the water system had a conservation education and public awareness program, whether or not the water system had a withdrawal source within the Chattahoochee River Basin or not, and number of pricing blocks that were in place in their billing scheme. Using the best functional form of the linear regression model that was produced, the model hypotheses were checked for significance of the variables using t-tests. Many variables were found to have expected positive and negative relationships with the dependent variable with the only two variables of GDP and source having opposite relationships than expected. The model was checked for issues with collinearity between the variables and was found to have none. The RESET test was used to find no instances of misspecification. Possible problems with heteroscedasticity were corrected by weighting the population change variable. Finally, using the weighted variable regression results, the full model was proven to have significance with the use of the f-test.

The variables of population, income and education program proved to be the significant variables within the model. Rising populations and income in the water systems' covered area would likely cause the residential price of water to increase, while the existence of a conservation education and public awareness program within the area provided by the water system would significantly decrease the residential price of water. The education program variable with its estimate represents the largest level of significance within the model. These findings describe a situation where a more social aspect variable of the regression model was found to be more influential than many of the other popular economic variables. This finding creates an interesting outlook on water conservation measures and also the area of public awareness. It is not know through this research what other measures these water systems have taken in the areas of conservation and awareness; however the fact that the water system has a conservation education and public awareness program is a strong indicator that the system is doing more. These programs in many places are an expense to the water system that may not result in a direct immediate benefit for the water system but are still being implemented in more systems. Informing the residential consumers about their water resource and their actions dealing with the resource can create more knowledgeable residents. This can result in a desire by the residents for the most efficient and most beneficial actions by their water system which could overall result in a change in prices. Direct research into conservation and public awareness programs by water systems could prove to further confirm this resulting influence over prices.

## References

Brill, E., Hochman, E. and David Zilberman. 1997. "Allocation and Pricing at the Water District Level." American Journal of Agricultural Economics 79(3):952-963.

Erhardt, Carl. 1992. "The Battle Over 'The Hooch': The Federal-Interstate Water Compact and the Resolution of Rights in the Chattahoochee River." Stanford Environmental Law Journal 11:200-228.

Hill, R. Carter, Griffiths, William E., and Guay C. Lim. 2008. Principles of Econometrics, 3rd. ed. USA: John Wiley & Sons, Inc.

Kriesel, Warren. 2010. Georgia Statistics System. University of Georgia.

Metropolitan North Georgia Water Planning District. 2010. 2010 Metro Water District Plan Implementation Review. Atlanta, GA.

Metropolitan North Georgia Water Planning District. 2011. Activities and Progress Report – 2010. Atlanta, GA.

Metropolitan North Georgia Water Planning District. 2011. Water Metrics Report – January 2011. Atlanta, GA. Perloff, Jeffrey M. 2008. Microeconomics: Theory & Applications with Calculus. Boston: Pearson Addison Wesley, 2008.

United States Census. 2010. Population Distribution and Change: 2000 to 2010. Washington DC.

Upper Chattahoochee Riverkeeper. 2011. Filling the Water Gap – Conservation Successs and Missed Opportunities in Metro Atlanta. Atlanta, GA.

Varela-Ortega, C., Sumpsi, Jose M., Garrido A., Blanco, M. and Eva Iglesias. 1998. "Water pricing policies: public decision making and farmers' response: implications for water policy." Agricultural Economics 19:193-202.