Institutional, Regulatory, and Municipality-Specific Factors Affecting Wastewater Prices: The Case of North Carolina Municipalities

Suho Bae
Graduate School of Governance
Sungkyunkwan University
53, Myeongnyun-dong 3-ga, Jongno-gu
Seoul, 110-745, Republic of Korea
baes@skku.edu

Seong-gin Moon
Department of Public Administration
Inha University
253, Yonghyun-dong, Nam-gu
Incheon 402-751, Republic of Korea
moons@inha.ac.kr

Sung-Woo Hong
Department of Public Administration
Daejin University
komell@hanmail.net

Presented at the Annual Conference of the Association for Public Policy Analysis and Management, May 25-27, 2013 in Shanghai, China.

Authors' Note: The corresponding author's email is: baes@skku.edu.

ABSTRACT

The public sector, including local governments, is mainly responsible for the delivery of wastewater services in the United States. But wastewater prices are considerably different from place to place. This paper examines what factors and characteristics contribute to those differences. To do so, it employs the price equation for wastewater services and utilizes North Carolina municipality data for years 2000 and 2002.

Empirical findings indicate that several institutional arrangements and characteristics are important in explaining wastewater prices. When sewer bill is charged on a monthly basis or when a city delivers wastewater services to people outside the city limits and charges different rates to them compared with citizens inside the city limits, wastewater prices get decreased. On the contrary, when a city levies minimum charges, when an increasing rate structure is used, or when the Council-Manager form of government is adopted, wastewater prices get increased.

Several supply factors and characteristics affect wastewater prices as well. When a city has large wastewater treatment capacity, when it has its own treatment facility, or when it has a grease reduction program, wastewater prices get decreased. When a city implements an infiltration and inflow (I&I) maintenance program or when it implements a stormwater management program, wastewater prices get increased.

Keywords: price of wastewater services; institutional arrangements and characteristics; North Carolina municipalities

1. Introduction

Wastewater services are one of public services that the public sector, including local governments, takes full responsibility for providing to households and businesses (Jacobson and Tarr, 1996). This public service helps improve public health conditions and quality-of-life environments, enhance living standards, and do business activity (Bae et al., 2009; Haughwout, 2001; Kessides, 1962).

However, prices of wastewater services are considerably different across municipalities in North Carolina. As shown in Table 1, when households produce 25,000 gallons (25 KGs) of wastewater for a month, average monthly wastewater charges per 1,000 gallons (KG) among 215 municipalities in North Carolina is $3.10. But households in Broadway pay $8.50 per KG per month, while those in Spindale pay $0.40. In other words, households in Broadway pay more than 21 times as much as those in Spindale.

[Table 1] Monthly Wastewater Charges per KG, 2002 -- *inserted*

This paper examines factors and characteristics that contribute to geographical differences in prices of wastewater services, using municipality data in North Carolina. By limiting our focus to a state, this paper can include more municipality-specific factors and characteristics and get more precise estimations, while controlling the influences of federal and state policies and regulations on prices of wastewater services. The major foci of the paper are on the following areas: (1) institutional arrangements and characteristics of municipality; (2) local regulations regarding wastewater services; (3) supply factors and characteristics; and (4) natural environments and local characteristics. Using the data from the 2000 and 2002 survey results conducted by the North Carolina League of Municipalities (NCLM), this paper employs the instrumental variable (IV) method to

estimate the price differences in wastewater services across municipalities in North Carolina.

This paper has further sections. In the next section, it develops and discusses the conceptual model to explain geographical differences in the prices of wastewater services. The price equation for wastewater services needs to be understood, along with its demand equation, under the simultaneous equations framework. In the following section, the empirical model is presented for empirical estimation of wastewater price. Then, the variables and data sources employed for empirical estimation are defined, along with descriptive statistics. It presents empirical findings. The final section summarizes empirical findings, and concludes some important findings, along with study limitations.

2. Conceptual Model of Prices of Wastewater Services

To understand the factors that explain the variation in wastewater prices across localities and regions, we construct the price equation for wastewater services, combined with its demand equation, under a simultaneous equations framework (Bae, 2007; Bae et al., 2009; Barkatullah, 2002; Halvorsen, 1975; Merrett, 1997; Renwick et al., 1998). The general form of the demand equation for wastewater services can be written as:

$$Q = f(P, X, u) \qquad [1]$$

where Q is the quantity demanded of wastewater treatment, P is the price of wastewater services and endogenous as microeconomic theory suggests, and u is an error term. X is a vector of the relevant variables influencing Q, including median household income, number of sewer accounts, number of households, frequency distribution of user types

(e.g., household, agricultural, industrial, and commercial users), regional output level, population density, and size of population served.

The general form of the price equation for wastewater services can be written as:

$$P = g(Q, Z, v) \quad [2]$$

where Q represents economies of scales where the cost of wastewater services per unit decreases as the quantity of wastewater services demanded increases. Economies of scale are fully reflected in prices of wastewater services, if the cost of wastewater services is fully taken into account in setting up the price of wastewater services. But it needs to be noted that the price of wastewater services is not necessarily same as the cost of wastewater services, if wastewater price is not set up to fully recover cost of wastewater services (Bae, 2007; Bae et al., 2009). Z is a vector of the relevant variables influencing P and u is an error term. Relevant variables might include (1) institutional arrangements and characteristics of municipality, (2) government regulations (including environmental, health, and safety regulations), (3) supply-side factors and characteristics, and (4) natural environments (including natural endowments and physical geography) and local characteristics in delivery of wastewater services. These four categories of factors might affect prices of wastewater services and contribute to price differences in wastewater services across municipalities in North Carolina.

3. Empirical Model of Prices of Wastewater Services

From Equation [2], the price equation for wastewater services can be written as for empirical estimation:

$$\ln P_i = \beta_0 + \beta_1 \ln Q_i + \sum_{j=1}^{9} \phi_j INST_i^j + \sum_{k=1}^{3} \delta_k LOCALREG_i^k + \sum_{l=1}^{7} \varphi_l SUPPLY_i^l + \sum_{m=1}^{2} \eta_m LOCALENV_i^m + \sum_{n=1}^{6} \gamma_n RG_i^n + \lambda Y2002_i + \varepsilon_i \quad [3]$$

where all continuous variables are in the form of natural logarithm and all monetary variables are inflation adjusted in 2002 dollars using consumer price index. P_i is the price of wastewater services, as measured as monthly wastewater charges per 1,000 gallons (KG) in municipality *i*. In Equation [3], five dependent variables are employed for empirical estimation on price differences in wastewater services for residential users across municipalities in North Carolina:

- Monthly charges per KG (residential, 3 KGs)
- Monthly charges per KG (residential, 10 KGs)
- Monthly charges per KG (residential, 25 KGs)
- Monthly charges per KG (residential, 100 KGs)
- Monthly charges per KG (residential, 1,000 KGs)

Wastewater utilities adopt different pricing mechanisms such as uniform rates, increasing block rates, or decreasing block rates, and they also use different number of blocks and tariffs. Thus, it is difficult to find one universal measure, i.e., price of wastewater services per KG across municipalities. Stratified cases of wastewater prices for residential users are able to account for these differences in pricing rate structures and number of blocks (Bae, 2007; Bae et al., 2009; Shaw, 2005, pp. 109-121). For example, monthly charges per KG (residential, 25 KGs) means the dollar amounts per KG charged to a residential user for whom 25 KGs of wastewater are treated for one month.

Q_i is the quantity of wastewater services demanded, which is endogenous to P_i. But since data about Q_i is not available, this paper employs the instrumental variable (IV) method to best represent the quantity of wastewater services demanded and avoid the simultaneity bias that can be caused by an OLS estimation of Equation [3]. Two variables are employed as instrumental variables for Q_i in municipality *i*: number of city sewer accounts and number of households. In addition, standard errors are adjusted with heteroskedasticity-consistent standard errors (Verbeek, 2000, pp.80-81). This paper uses the Stata statistical package.

Nine variables are employed in Equation [3] to represent institutional arrangements and characteristics of municipality *i* ($INST_i$). The first variable is form of municipal government. There are two basic forms of municipal government: the Mayor-Council form; and the Council-Manager form. In the mayor-council form, prices are likely to be lower than in the council-manager form, because local politicians and public officials may pay more attention to lowering prices than improving efficiency in order to avoid political fallout. On the other hand, professional managers in the council-manager form may bring leadership and expertise to wastewater service delivery, thus leading to high efficiency (and lower prices) (Bae, 2007; Fleer, 1994, pp. 199-212). Thus, it is a priori unknown which form of government will increase or decrease wastewater prices.

The second variable is whether a city delivers wastewater services to people outside the city limits: coded as 1 if the city delivers this public service to people outside the city limits, otherwise, coded as 0. The third variable is an interaction variable between the delivery of wastewater services to outside-city people and whether inside-city rates are different from outside-city rates. When a city delivers this service to outside-city

residents and inside-city rates are not same as outside-city rates, it is coded as 1, but otherwise it is coded as 0. Generally, when inside-city and outside-city rates are not same, the city charges higher prices to outside-city people than its citizens. This behavior may transfer the whole or some portion of costs of wastewater services for citizens to outside-city people, thus lowering prices of wastewater services for citizens. Then, the interaction term is expected to be negatively related with prices of wastewater services.

Fourth, when a city charges minimum monthly sewer charges regardless the volumes of wastewater treated, price of wastewater services is expected to be higher than otherwise. Fifth, when a city adopts decreasing sewer rate structures, price of wastewater services is expected to be lower than under uniform rate structures. Sixth, when a city adopts increasing sewer rate structures, it is expected to be higher than under uniform rate structures. The seventh variable is whether a city has its own electric system. Price of wastewater services is likely to be higher in case of owning its electric system, because the generation, transmission, and delivery of electric services produce more wastewater. Eighth, when sewer bill is charged on a monthly basis, price of wastewater services is likely to be higher than when it is charged on a bi-monthly or quarterly basis, probably because high prices are difficult to be recognized on a monthly basis. The ninth variable is whether other item(s) is billed on sewer bill, including garbage collection, natural gas, and electric services. It is a priori unknown whether other item(s) being billed on sewer bill will increase wastewater prices.

Three variables are employed to represent local ordinances regarding wastewater services in municipality i ($LOCALREG_i$). The first variable is whether a city has ordinance regulating sewer use. If the city has that ordinance, price of wastewater services is likely

to be higher than otherwise, because observing the ordinance adds more financial burden. The second variable is whether a city has pre-treatment ordinance regulating sewer use. Price of wastewater services in a city with this ordinance is likely to be higher than in a city without the ordinance. The third variable is whether a city has mandatory connection ordinance for sewer system. The existence of mandatory connection ordinance for sewer system is also likely to increase costs of wastewater services, thus resulting in high prices.

Seven variables are employed to represent supply factors and characteristics in municipality i ($SUPPLY_i$). The first variable is age in years of oldest part of sewer collection system. It is expected to be positively related to price of wastewater services, because old sewer collection system may imply inefficiency in the operation and management of the sewer system. The second variable is whether a city has its own sewage treatment facility. In case that wastewater in a city is treated by other entity, it may charge high price against the city, compared with the case that the city has its own sewage treatment facility. Thus, in the former case, price of wastewater services is likely to be higher than in the latter case. Third, wastewater treatment capacity in 1,000 gallons per day (KGPDs) is expected to be negatively related to price of wastewater services. The fourth variable is whether a city has an infiltration and inflow (I&I) maintenance program. Since low level of infiltration and inflow into the sewer system implies high efficiency in the operation and management of the sewer system, I&I maintenance program may negatively related to price of wastewater services. The fifth variable is whether a city has a stormwater management program. Since additional resources may be required for implementing this program, the program is likely to be positively related to price of wastewater services. Sixth, additional resources are needed in removing nutrients from

wastewater. Thus, removal of nutrients from wastewater may increase price of wastewater services. The seventh variable is whether a city has grease reduction program. If the city has the program, price of wastewater services is likely to be lower than otherwise, because the implementation of this program may encourage households to reduce grease in wastewater produced, thus leading to low costs (and low prices) of wastewater services.

Natural environments and local characteristics also may contribute to price differences in wastewater services across municipalities ($LOCALENV_i$ and RG_i). Along with six regional dummies, this paper employs two variables for empirical estimation: median household income, and whether a municipality is located in a metropolitan statistical area (MSA). Six regional dummies are employed to control for unexplained regional variations in wastewater prices across municipalities in North Carolina. As shown in Figure 1, North Carolina is classified into seven economic development regions: Advantage West, Charlotte, Piedmont Triad, Research Triangle, Northeast, Eastern, and Southeast (Connaughton and Madsen, 2007). Geographical location, natural environments, level of economic development, and economic structures are similar across municipalities within each region. The Advantage West region is used as the base category for the other six regions. One year dummy ($Y2002_i$) is employed to control for yearly unexplained variations in wastewater prices. Year 2000 is used as the base category for the year dummy ($Y2002_i$).

[Figure 1] Seven Economic Development Regions in North Carolina -- *inserted*

Data are obtained from several sources: 2000 & 2002 survey results conducted by North Carolina League of Municipalities (NCLM); *North Carolina County and*

Municipal Financial Information, North Carolina Department of State Treasurer; *Forms of Government and Methods of Election in North Carolina Cities*, UNC School of Government; *MSAs in the state NC, Business and Economic Statistics*, Rand California Statistics; and *Census 2000 Demographic Profiles*, Census Bureau. The unit of analysis is municipalities in North Carolina.

4. Descriptive Statistics

Table 2 presents descriptive statistics on the variables employed for empirical analysis. As shown in Table 2, average monthly charges per KG decreases from $4.70 to $2.87, as the level of wastewater treated increases from 3 KGs to 1,000 KGs. Average monthly charges per KG varies across North Carolina regions, ranging from $2.48 in Advantage West region to $5.57 in Eastern region. Number of sewer accounts and number of households are relatively large in three regions – Piedmont Triad, Research Triangle, and Charlotte, while they are relatively small in two regions – Advantage West, and Northeastern.

On average, about 14 percent of municipalities adopt decreasing rate structures, ranging from 7 percent in Northeastern region to 25 percent in Advantage West region. On average, about 6 percent of municipalities adopt increasing rate structures, varying from 0 percent in Northeastern region to 10 percent in Advantage West region. About 74 percent to 89 percent of municipalities deliver wastewater services to people outside the city limits. About 61 percent to 76 percent of municipalities across North Carolina regions deliver wastewater services to and charge different prices to people outside the city limits, compared with citizens inside the city limits.

On average, about 84 percent of municipalities levy minimum charges regardless how many KGs of wastewater residential users produce, ranging from 67 percent in Research Triangle region to 95 percent in Northeastern region. In about 11 percent of municipalities, sewer bill is charged on a monthly basis, varying from 0 percent in Northeastern region to 47 percent in Piedmont Triad. In about 65 percent to 97 of municipalities, other item(s) is billed on sewer bill. About 7 percent to 38 percent of municipalities have their own electric systems. On average, about 72 percent of municipalities adopt the Council-Manager form of government, ranging from about 37 percent in Northeastern region to 89 percent in Piedmont Triad.

[Table 2] Descriptive Results -- *inserted*

About 84 percent to 95 percent of municipalities have sewer use ordinances regarding permitted and non-permitted uses of the sewer system. About 56 percent to 81 percent have pretreatment ordinances. About 58 percent to 95 percent have mandatory connection ordinances.

Municipalities have relatively large capacity to treat wastewater in three regions – Northeastern, Piedmont Triad, and Charlotte, while municipalities have relatively small capacity in three regions – Advantage West, Eastern, and Southeastern. Average age in years of oldest part of sewer collection system is about 46 years in Northeastern region to about 61 years in Research Triangle region. About 79 percent of municipalities have their own treatment facilities, ranging from 68 percent in Charlotte region to 93 percent in Northeastern region. About 79 percent of municipalities have infiltration and inflow maintenance programs, ranging from 70 percent in Advantage West region to 93 percent in Northeastern region. About 42 percent to 57 percent of municipalities have grease

reduction programs, while about 7 percent to 20 percent of municipalities have stormwater management programs. About 39 percent to 66 percent of municipalities remove nutrients from wastewater such as nitrogen or phosphorous.

Municipalities have relative large median household income in Research Triangle and Charlotte regions, while they have relatively small income in Northeastern region. No municipality in Northeastern region is located in metropolitan statistical areas (MSAs), while about 63 percent to 68 percent of municipalities are located in MSAs in three regions – Piedmont Triad, Research Triangle, and Charlotte.

5. Empirical Results

This paper examines what factors and characteristics explain the variations in wastewater prices in North Carolina municipalities. It employs the instrumental variable estimation method. It employs five stratified wastewater prices: (1) monthly wastewater charges per KG (residential, 3 KGs); (2) monthly wastewater charges per KG (residential, 10 KGs); (3) monthly wastewater charges per KG (residential, 25 KGs); (4) monthly wastewater charges per KG (residential, 100 KGs); and (5) monthly wastewater charges per KG (residential, 3 KGs). In addition, it accounts for four categories of independent variables: (1) institutional arrangements and characteristics; (2) local regulations on sewer services; (3) supply-side factors and characteristics; and (4) natural environments and local characteristics. As shown in Table 3 through Table 7, all coefficients generally show expected signs. R^2's are about 0.15 to 0.29 across all the estimated models, and F values are large, implying the overall significance of the estimated models.

5.1 Monthly Wastewater Charges per KG (Residential, 3 KGs)

Table 3 shows the empirical results for monthly wastewater charges per KG (residential, 3 KGs). Among the two instrumental variables for the quantity of wastewater treated, the number of sewer accounts is negative and significant at the 5 percent level. In other words, along with the 10 percent increase in the number of sewer accounts, monthly charges per KG decrease by about 0.5 percent.

Among the nine variables about institutional arrangements and characteristics, only bill frequency is negative and significant at the 5 percent level. Contrary to general expectation, when sewer bill is charged on a monthly basis, monthly charges per KG is significantly lower than when it is charged on a bi-monthly or quarterly basis. No local ordinance on wastewater services is significant.

[Table 3] Empirical Results: Monthly Wastewater Charges per KG (Residential, 3 KGs) -- *inserted*

Among the seven variables representing supply-side factors and characteristics, three variables are significant: treatment capacity, own treatment facility, and stormwater management. Along with a 10 percent increase in wastewater treatment capacity, monthly charges per KG decrease by about 0.4 percent to 0.6 percent. When a city has its own facility to treat wastewater, monthly charges per KG are significantly lower than otherwise. When a city has a stormwater management program, they are significantly larger than otherwise.

In five regions – that is, Eastern, Southeastern, Northeastern, Research Triangle, and Charlotte regions, wastewater prices are significantly higher than in the base region, Advantage West. Wastewater prices are significantly higher in 2002 than in 2000.

5.2 Monthly Wastewater Charges per KG (Residential, 10 KGs)

Table 4 shows the empirical results for monthly wastewater charges per KG (residential, 10 KGs). When a city delivers wastewater services to people outside the city limits and charges different rates to them compared with citizens inside the city limits, wastewater prices for citizens are significantly lower than otherwise. There might be two reasons. The first reason is that a city levies high price against outside-city residents to transfer some cost of service delivery for inside-city residents to outside-city residents in order to avoid political criticisms from inside-city residents. The second one is that delivery of wastewater services to outside-city residents requires additional investment in wastewater collection and treatment. Which one is more dominant cannot be tested empirically in this paper, because of data unavailability. In case of levying minimum charges to citizens, wastewater prices are significantly higher than otherwise. When sewer bill is charged on a monthly basis, they are significantly lower than when being charged on a bi-monthly or quarterly basis.

[Table 4] Empirical Results: Monthly Wastewater Charges per KG (Residential, 10 KGs) -- *inserted*

Mandatory connection ordinance is positive and significant. In other words, when a city has an ordinance requiring mandatory connection to the sewer system, monthly charges are significantly higher than when the city does not.

Treatment capacity has significant negative effects on wastewater prices. Along with a 10 percent increase in treatment capacity, monthly charges per KG decrease by about 0.7 percent to 0.8 percent. When a city has its own treatment facility, monthly

charges are significantly lower than otherwise. When a city has an infiltration and inflow (I&I) maintenance program or a stormwater management program, wastewater prices are significantly higher than otherwise.

Median household income significantly contributes to prices of wastewater services. In other words, a 10 percent increase in median household income results in about 1.5 percent to 1.6 percent increase in monthly charges per KG. In four regions – Eastern, Southeastern, Research Triangle, and Charlotte regions, prices of wastewater services are significantly higher than Advantage West region. They are significantly higher in 2002 than in 2000.

5.3 Monthly Wastewater Charges per KG (Residential, 25 KGs)

Table 5 shows the empirical results for monthly wastewater charges per KG (residential, 25 KGs). Among the nine variables representing institutional arrangements and characteristics, three variables are significant: increasing rate structure, minimum charges, and form of government. When an increasing rate structure is adopted, prices of wastewater services are significantly higher than when a decreasing or uniform rate structure is adopted. When a city levies minimum charges to residential users regardless the amounts of wastewater treated, wastewater prices are significantly higher than otherwise. In the council-manager form of government, wastewater prices are significantly higher than in the mayor-council form. This finding is contrary to our general expectation that more efficiency and cost reduction of public service delivery is realized under the former form of government than the latter form. No variable about local ordinance is significant.

[Table 5] Empirical Results: Monthly Wastewater Charges per KG (Residential, 25 KGs) -- *inserted*

Four variables representing supply factors and characteristics are significant. Along with a 10 percent increase in treatment capacity, monthly charges per KG decrease by about 0.9 percent to 1.1 percent. Having a city's own treatment facility leads to low prices of wastewater services. An infiltration and inflow (I&I) maintenance program or a stormwater maintenance program contributes to high prices.

In three regions – Eastern, Research Triangle, and Charlotte regions, monthly charges per KG are significantly higher than Advantage West region. They are significantly higher in 2002 than in 2000.

5.4 Monthly Wastewater Charges per KG (Residential, 100 KGs)

Table 6 shows the empirical results for monthly wastewater charges per KG (residential, 100 KGs). When an increasing rate structure is adopted, prices of wastewater services are significantly higher than when a decreasing or uniform rate structure is adopted. When a city levies minimum charges regardless the amounts of wastewater treated, wastewater prices are significantly higher than otherwise. When the Council-Manager form of government is adopted, wastewater prices are significantly higher when the Mayor-Council form is adopted. No ordinance variable is significant.

[Table 6] Empirical Results: Monthly Wastewater Charges per KG (Residential, 100 KGs) -- *inserted*

Wastewater treatment capacity has significant negative effects on wastewater prices. Along with a 10 percent increase in treatment capacity, monthly charges per KG

increase by about 1.3 percent to 1.4 percent. When a city has its own treatment facility or implements a grease reduction program, wastewater prices are significantly lower than otherwise. On the contrary, when a city implements an infiltration and inflow (I&I) maintenance program or a stormwater management program, wastewater prices are significantly higher than otherwise.

In three regions – Eastern, Research Triangle, and Charlotte regions, monthly charges per KG is significantly higher than Advantage West region. They are significantly higher in 2002 than in 2000.

5.5 Monthly Wastewater Charges per KG (Residential, 1,000 KGs)

Table 7 shows the empirical results for monthly wastewater charges per KG (residential, 1,000 KGs). Among the nine variables representing institutional arrangements and characteristics, minimum charges and form of government are significant. When a city levies minimum charges or when the city adopts the Council-Manager form as form of government, wastewater prices are significantly higher than otherwise. No local ordinance is significant.

[Table 7] Empirical Results: Monthly Wastewater Charges per KG (Residential, 1,000 KGs) -- *inserted*

Wastewater treatment capacity is negative and significant. In other words, along with a 10 percent increase in treatment capacity, monthly charges per KG decrease by about 1.8 percent to 1.9 percent. When a city has its own treatment facility or implements a grease reduction program, wastewater prices are significantly lower than otherwise.

In two regions – Research Triangle, and Charlotte regions, monthly charges per KG are significantly higher than Advantage West region. They are significantly higher in 2002 than in 2000.

5.6 Summary

Number of sewer accounts, used as instrumental variable for the quantity of wastewater treated, is partially significant in some empirical estimations. An increase in the number of sewer accounts decreases wastewater prices, as shown in Table 3 where the dependent variable is monthly charges per KG (residential, 3 KGs) in the natural logarithm form.

Several institutional arrangements and characteristics affect wastewater prices. When sewer bill is charged on a monthly basis or when a city delivers wastewater services to people outside the city limits and charges different rates to them compared with citizens inside the city limits, wastewater prices for citizens get decreased. On the contrary, when a city levies minimum charges, when an increasing rate structure is adopted, or when the Council-Manager form of government is adopted, wastewater prices get increased.

Several supply factors and characteristics affect wastewater prices. When a city has large wastewater treatment capacity, when it has its own treatment facility, or when it has a grease reduction program, wastewater prices get decreased. When it has an infiltration and inflow (I&I) maintenance program or a stormwater management program, wastewater prices get increased.

As shown in Table 4, median household income has some marginal positive effects on wastewater prices. As shown in Tables 3 to 7, there are some large differences in wastewater prices across regions.

6. Conclusions

The public sector is mainly responsible for provision of wastewater services. But prices of wastewater services are considerably different across local places in the United States. This paper analyzed what factors and characteristics contribute to those differences. To do so, it employed the price equation for those services and utilized North Carolina municipality data for years 2000 and 2002. It accounted for four categories of variables in empirical models: (1) institutional arrangements and characteristics; (2) local regulations regarding wastewater services; (3) supply-side factors and characteristics; and (4) natural environments (including natural endowments and physical geography) and local characteristics.

Empirical findings indicate that several institutional and supply factors explain price differences in wastewater services across North Carolina municipalities. The institutional factors that affect wastewater prices are bill frequency, service delivery to people outside the city limits and different charges against them, minimum charges, increasing rate structure, and form of government. The supply factors affecting wastewater prices are wastewater treatment capacity, own treatment facility, grease reduction program, infiltration and inflow (I&I) maintenance program, and stormwater management program. These findings suggest important policy implications, because

most of these institutional and supply factors are under control by policy makers in municipalities.

This paper used only North Carolina data. Further research needs to be conducted in order to expand our understanding of price differences in wastewater in other states and countries. In addition, we need to conduct future research to understand geographical differences in the availability, reliability, and quality of wastewater services. For example, wastewater is still not sufficiently treated for many people around the world, particularly in developing countries. They are still in trouble with access to clean water and good quality of wastewater services.

VI. References

Averch, H., & Johnson, L.O. 1962. Behavior of the firm under regulatory constraint. *American Economic Review*, 52, 1052-1069.

Bae, S. 2005. *Infrastructure, Private-Sector Production and Location: Sectoral and Regional Differences*. Ph.D. dissertation, University of North Carolina at Chapel Hill.

Bae, S., 2007. Explaining geographical differences in water prices: do institutional factors really matter? The Review of Regional Studies 37(2), 207-250.

Bae, S., Gen, S., & Moon, S. 2009. Geographic, institutional, and facility factors affecting differences in prices for wastewater services. Working paper. 34 pages.

Barkatullah, N., 2002. OLS and instrumental variable price elasticity estimates for water in mixed effect model under a multipart tariff structure. London Economics. Available at http://www.londecon.co.uk/Publications/DEMD1.pdf, May 2006.

Census Bureau, Census 2000 Demographic Profiles. Retrieved from June 10, 2008 from http://censtats.census.gov/pub/Profiles.shtml.

Connaughton, J.E., & Madsen, R. A. 2007. The economic impacts of the North Carolina motorsports industry. *Economic Development Quarterly (EDQ)*, 21(2), 185-197.

Fleer, J. D. "Grassroots Governments: The Many Who Govern," in *North Carolina Government and Politics*, edited by J. D. Fleer. Lincoln, NE: University of Nebraska Press, 1994, 197–216.

Halvorsen, R., 1975. Residential demand for electric energy. Review of Economics and Statistics 57, 12-18.

Haughwout, A.F., 2001. Infrastructure and social welfare in metropolitan America. Economic Policy Review, Federal Reserve Bank of New York, 1-16.

Kessides, C., 1996. A review of infrastructure's impact on economic development, in: Batten, D.F., Karlsson, C. (Eds.), Infrastructure and the Complexity of Economic Development. New York: Springer, pp. 213-230.

Jacobson, C.D., & Tarr, J.A. (1996). No single path: ownership and financing of infrastructure in the 19th and 20th centuries. In A. Mody (Ed.), *Infrastructure Delivery: Private Initiative and the Public Good*. Washington, D.C.: International Bank for Reconstruction and Development, 1-35.

Merrett, S., 1997. Effective demand and the price of water, in: Introduction to the Economics of Water Resources: An International Perspective. New York: Rowan & Littlefield Publishers, pp. 53-83.

National Climatic Data Center (NCDC). (2002). *Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971 – 2000.* Washington, D.C.: National Oceanic and Atmospheric Administration (NOAA).

North Carolina League of Municipalities (NCLM), *How Much Does Clean Water Cost? 2000*, Raleigh, North Carolina.

North Carolina League of Municipalities (NCLM), *How Much Does Clean Water Cost? 2002*, Raleigh, North Carolina.

North Carolina Department of State Treasurer, *North Carolina County and Municipal Financial Information*, Raleigh, North Carolina. Retrieved November 10, 2004 from http://www.treasurer.state.nc.us/lgc/units/unitlistjs.htm.

Rand California Statistics, *MSAs in the state NC, Business and Economic Statistics*. Retrieved June 15, 2008 from http://ca.rand.org/stats/economics/MSA/NC.html.

Renwick, M., Green, R., McCorkle, C., 1998. Measuring the Price Responsiveness of Residential Water Demand in California's Urban Areas. Sacramento: California Department of Water Resources.

Renzetti, S. (2000). An empirical perspective on water pricing reforms. In A. Dinar, *The Political Economy of Water Pricing Reform*. New York: Oxford University Press, 123-140.

Shaw, W.D., 2005. *Water Resource Economics and Policy: An Introduction*. Northampton, MA: Edward Elgar.

UNC School of Government, *Forms of Government and Methods of Election in North Carolina Cities*, Chapel Hill, NC: The University of North Carolina. Retrieved July 12, 2008 from http://www.sog.unc.edu/pubs/FOG/index.php.

Verbeek, M. 2000. *A Guide to Modern Econometrics*. New York: John Wiley & Sons.

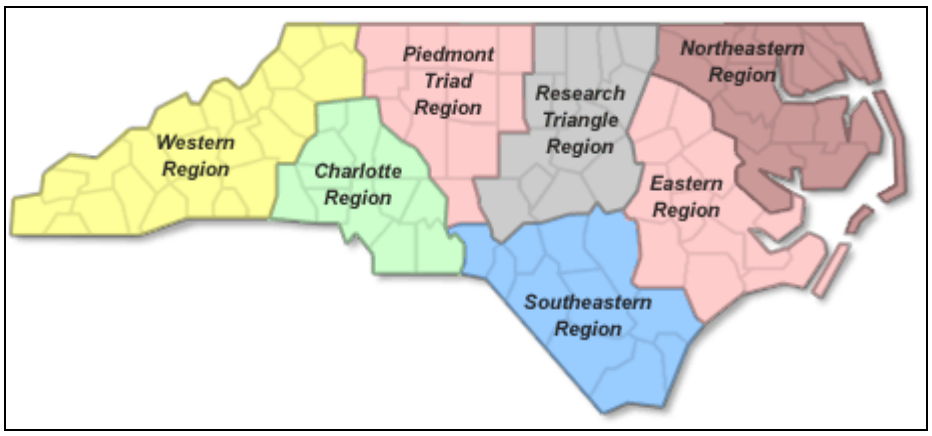
[Table 1] Monthly Wastewater Charges per KG, 2002

City	Region	Monthly Wastewater Charges ($ per 1 KG)
Broadway	Research Triangle	8.50
Middlesex	Eastern	7.75
Stanley	Charlotte	7.16
Oak Island	Southeastern	6.96
Youngsville	Research Triangle	6.60
Mount Gilead	Piedmont Triad	6.40
Newland	Advantage West	6.36
Burgaw	Southeastern	6.24
Morrisville	Research Triangle	6.18
Trinity	Piedmont Triad	6.00
Holly Springs	Research Triangle	6.00
Clyde	Advantage West	6.00
High Shoals	Charlotte	5.76
Troutman	Charlotte	5.75
Snow Hill	Eastern	5.55
Elkin	Piedmont Triad	5.51
Hookerton	Eastern	5.44
Wake Forest	Research Triangle	5.23
Selma	Research Triangle	5.13
Beaufort	Eastern	5.11
Charlotte	Charlotte	1.70
Marion	Advantage West	1.69
Robersonville	Northeastern	1.60
Mount Holly	Charlotte	1.54
Whiteville	Southeastern	1.52
Murphy	Advantage West	1.50
Raleigh	Research Triangle	1.50
Rockingham	Southeastern	1.46
Raeford	Southeastern	1.44
Mayodan	Piedmont Triad	1.41
Drexel	Advantage West	1.37
Valdese	Advantage West	1.33
Windsor	Northeastern	1.32
Wilkesboro	Advantage West	1.30
Ellerbe	Southeastern	1.29
Spruce Pine	Advantage West	1.27
Woodland	Northeastern	0.93
Franklinville	Piedmont Triad	0.88
Canton	Advantage West	0.84
Spindale	Advantage West	0.40
Average:		**3.10**

Source: 2002 Water and Sewer Rates and Services Survey, North Carolina League of Municipalities (NCLM).

Note: Monthly wastewater charges per KG (1,000 gallons) calculated on the basis of 25 KGs for residential use.

[Figure 1] Seven Economic Development Regions in North Carolina



Source: Connaughton and Madsen (2007).

[Table 2] Descriptive Results

Category	Variable	All Regions		Advantage West		Eastern		Southeastern		Northeastern		Piedmont Triad		Research Triangle		Charlotte	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Wastewater prices	Charges per KG (3 KGs)	4.70	1.88	3.82	1.46	5.57	1.87	4.67	1.87	5.02	2.13	3.81	1.79	5.09	1.57	4.85	1.83
	Charges per KG (10 KGs)	3.44	1.31	2.88	1.31	3.74	1.16	3.31	1.30	3.28	1.46	3.02	1.22	4.09	1.36	3.60	1.10
	Charges per KG (25 KGs)	3.10	1.35	2.64	1.32	3.25	1.27	2.99	1.35	2.83	1.45	2.79	1.18	3.83	1.43	3.23	1.21
	Charges per KG (100 KGs)	2.92	1.43	2.50	1.35	2.99	1.41	2.76	1.44	2.61	1.48	2.63	1.08	3.73	1.50	3.09	1.39
	Charges per KG (1,000 KGs)	2.87	1.46	2.48	1.37	2.91	1.47	2.70	1.46	2.53	1.48	2.63	1.10	3.64	1.53	3.06	1.48
Instrumental variables for quantity of	Population	15,299	48,561	5,268	6,940	11,058	18,766	11,249	26,430	2,965	4,104	23,080	50,834	25,534	58,343	23,779	86,949
	Sewer Accounts	5,743	16,680	2,419	2,573	3,710	5,690	4,474	10,166	1,224	1,516	9,485	20,246	9,674	21,920	8,017	27,102
	Households	6,166	19,554	2,153	2,853	4,763	9,757	4,522	10,358	1,157	1,560	9,610	21,502	10,035	23,457	9,269	34,142
Institutional arrangements and characteristics	Decreasing	0.14	0.35	0.25	0.44	0.07	0.25	0.31	0.46	0.07	0.26	0.10	0.30	0.10	0.30	0.12	0.32
	Increasing	0.06	0.24	0.10	0.31	0.07	0.25	0.08	0.28	0.00	0.00	0.07	0.25	0.06	0.25	0.03	0.16
	Delivery Outside City	0.82	0.38	0.81	0.40	0.77	0.42	0.85	0.36	0.74	0.44	0.85	0.36	0.89	0.32	0.82	0.39
	Rate Difference	0.68	0.47	0.71	0.46	0.64	0.48	0.61	0.49	0.65	0.48	0.76	0.43	0.76	0.43	0.64	0.48
	Minimum Charge	0.84	0.37	0.91	0.29	0.81	0.39	0.90	0.30	0.95	0.21	0.83	0.38	0.67	0.48	0.85	0.36
	Bill Frequency	0.11	0.31	0.10	0.31	0.04	0.20	0.07	0.25	0.00	0.00	0.47	0.50	0.06	0.25	0.01	0.11
	Other Item(s) Billed	0.80	0.40	0.65	0.48	0.91	0.29	0.97	0.18	0.67	0.47	0.81	0.39	0.83	0.38	0.74	0.44
	Own Electricity	0.22	0.42	0.16	0.37	0.38	0.49	0.17	0.38	0.30	0.46	0.07	0.25	0.16	0.37	0.29	0.46
	Government Form	0.72	0.45	0.74	0.44	0.64	0.48	0.76	0.43	0.37	0.49	0.89	0.31	0.86	0.35	0.68	0.47
Local regulations	Sewer Use Ordinance	0.92	0.27	0.95	0.21	0.91	0.27	0.92	0.28	0.84	0.37	0.93	0.25	0.94	0.25	0.91	0.29
	Pretreatment Ordinance	0.70	0.45	0.74	0.44	0.56	0.48	0.73	0.45	0.56	0.50	0.81	0.39	0.77	0.42	0.74	0.44
	Mandatory Connection Ordinance	0.73	0.44	0.58	0.49	0.82	0.38	0.84	0.36	0.95	0.21	0.65	0.47	0.69	0.46	0.68	0.46
Supply-side factors and characteristics	Treatment Capacity	4,965	10,958	3,038	3,345	3,597	5,568	4,314	8,392	1,009	1,318	7,434	12,445	6,515	12,374	7,494	18,178
	Age of Sewer System	54.73	24.67	53.70	22.33	58.35	22.48	51.36	24.83	45.88	24.35	55.02	24.08	60.74	26.70	54.56	26.36
	Own Facility	0.79	0.40	0.84	0.37	0.80	0.40	0.90	0.30	0.93	0.26	0.79	0.41	0.70	0.46	0.68	0.47
	Infiltration & Inflow	0.79	0.39	0.70	0.46	0.87	0.31	0.73	0.45	0.73	0.44	0.79	0.39	0.93	0.25	0.79	0.39
	Grease Reduction	0.50	0.50	0.53	0.50	0.57	0.49	0.46	0.50	0.42	0.50	0.53	0.50	0.49	0.50	0.50	0.50
	Stormwater Management	0.15	0.36	0.12	0.32	0.20	0.39	0.19	0.39	0.07	0.26	0.14	0.34	0.16	0.37	0.15	0.36
	Nutrient Removal	0.47	0.44	0.39	0.44	0.47	0.45	0.46	0.48	0.44	0.49	0.43	0.44	0.66	0.40	0.41	0.40
Local characteristics	Household Income	35484	10455	32582	8204	34087	10114	32739	9938	27890	7055	36874	7549	42897	14289	38563	7816
	Urban	0.46	0.50	0.37	0.49	0.46	0.50	0.31	0.46	0.00	0.00	0.68	0.47	0.63	0.49	0.63	0.49
N		444		68		74		59		43		59		63		78	

[Table 3] Empirical Results: Monthly Wastewater Charges per KG (Residential, 3 KGs)

Dependent Variable: ln (Monthly Charges per 1,000 Gallons)	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value
Constant	1.017	0.888	0.25	1.129	0.891	0.21
ln (Sewer Accounts)	-0.050	0.025	0.05			
ln (Household)				-0.027	0.026	0.29
Decreasing	-0.050	0.062	0.42	-0.057	0.063	0.37
Increasing	-0.035	0.063	0.57	-0.035	0.063	0.59
Delivery Outside City	-0.003	0.069	0.97	-0.008	0.068	0.90
Rate Difference	-0.082	0.056	0.15	-0.080	0.056	0.15
Minimum Charge	-0.041	0.051	0.43	-0.036	0.051	0.48
Bill Frequency	-0.187	0.078	0.02	-0.199	0.080	0.01
Other Item(s) Billed	-0.040	0.052	0.44	-0.044	0.052	0.40
Own Electricity	0.072	0.048	0.13	0.069	0.048	0.15
Government Form	-0.034	0.055	0.54	-0.044	0.054	0.42
Sewer Use Ordinance	0.101	0.079	0.20	0.093	0.080	0.24
Pretreatment Ordinance	0.0001	0.0515	0.998	-0.005	0.052	0.92
Mandatory Connection Ordinance	0.074	0.047	0.12	0.070	0.048	0.15
ln (Treatment Capacity)	-0.042	0.020	0.03	-0.051	0.021	0.02
Age of Sewer System	0.001	0.001	0.55	0.000	0.001	0.68
Own Facility	-0.139	0.056	0.01	-0.154	0.055	0.01
Infiltration & Inflow	0.088	0.061	0.15	0.083	0.061	0.18
Grease Reduction	-0.010	0.040	0.81	-0.012	0.040	0.76
Stormwater Management	0.125	0.055	0.02	0.126	0.055	0.02
Nutrient Removal	0.004	0.046	0.93	0.005	0.045	0.92
ln (Household Income)	0.088	0.084	0.30	0.072	0.084	0.39
Urban	0.011	0.045	0.81	0.002	0.045	0.97
Eastern Region	0.302	0.071	0.00	0.306	0.072	0.00
Southeastern Region	0.187	0.081	0.02	0.187	0.082	0.02
Northeastern Region	0.166	0.087	0.06	0.164	0.088	0.06
Piedmont Triad Region	0.079	0.093	0.39	0.087	0.094	0.35
Research Triangle Region	0.298	0.074	0.00	0.300	0.074	0.00
Charlotte Region	0.188	0.072	0.01	0.198	0.072	0.01
Year 2002	0.070	0.036	0.06	0.065	0.037	0.08
N		444			444	
F value		5.20			5.01	
Prob > F		0.000			0.000	
R^2		0.2726			0.2674	

[Table 4] Empirical Results: Monthly Wastewater Charges per KG (Residential, 10 KGs)

Dependent Variable: ln (Monthly Charges per 1,000 Gallons)	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value
Constant	-0.311	0.865	0.72	-0.313	0.858	0.72
ln (Sewer Accounts)	-0.006	0.022	0.79			
ln (Household)				0.008	0.023	0.73
Decreasing	-0.007	0.060	0.91	-0.007	0.060	0.91
Increasing	0.084	0.058	0.15	0.086	0.059	0.15
Delivery Outside City	-0.021	0.067	0.75	-0.024	0.067	0.72
Rate Difference	-0.106	0.055	0.06	-0.103	0.056	0.06
Minimum Charge	0.074	0.044	0.09	0.079	0.044	0.07
Bill Frequency	-0.119	0.065	0.07	-0.121	0.066	0.07
Other Item(s) Billed	-0.025	0.051	0.62	-0.025	0.051	0.62
Own Electricity	0.024	0.041	0.56	0.022	0.041	0.59
Government Form	0.066	0.052	0.21	0.058	0.051	0.26
Sewer Use Ordinance	0.072	0.072	0.31	0.073	0.073	0.32
Pretreatment Ordinance	0.049	0.047	0.30	0.044	0.047	0.35
Mandatory Connection Ordinance	0.074	0.042	0.08	0.075	0.043	0.08
ln (Treatment Capacity)	-0.071	0.018	0.00	-0.077	0.019	0.00
Age of Sewer System	0.001	0.001	0.22	0.001	0.001	0.26
Own Facility	-0.167	0.054	0.00	-0.175	0.054	0.00
Infiltration & Inflow	0.117	0.054	0.03	0.115	0.054	0.03
Grease Reduction	-0.040	0.037	0.29	-0.040	0.037	0.29
Stormwater Management	0.153	0.048	0.00	0.149	0.049	0.00
Nutrient Removal	0.001	0.041	0.98	0.001	0.041	0.99
ln (Household Income)	0.155	0.084	0.07	0.152	0.082	0.07
Urban	0.018	0.041	0.65	0.012	0.041	0.76
Eastern Region	0.253	0.073	0.00	0.251	0.073	0.00
Southeastern Region	0.145	0.082	0.08	0.142	0.083	0.09
Northeastern Region	0.123	0.094	0.19	0.119	0.094	0.21
Piedmont Triad Region	0.131	0.085	0.13	0.130	0.086	0.13
Research Triangle Region	0.359	0.076	0.00	0.356	0.076	0.00
Charlotte Region	0.236	0.073	0.00	0.235	0.073	0.00
Year 2002	0.089	0.034	0.01	0.089	0.034	0.01
N		444			444	
F value		5.29			5.30	
Prob > F		0.000			0.000	
R^2		0.2846			0.2847	

[Table 5] Empirical Results: Monthly Wastewater Charges per KG (Residential, 25 KGs)

Dependent Variable: ln (Monthly Charges per 1,000 Gallons)	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value
Constant	-0.154	1.171	0.90	-0.218	1.165	0.85
ln (Sewer Accounts)	0.017	0.028	0.55			
ln (Household)				0.029	0.030	0.32
Decreasing	-0.017	0.064	0.79	-0.013	0.064	0.84
Increasing	0.170	0.077	0.03	0.172	0.078	0.03
Delivery Outside City	-0.025	0.082	0.76	-0.026	0.082	0.75
Rate Difference	-0.095	0.065	0.14	-0.092	0.065	0.16
Minimum Charge	0.131	0.057	0.02	0.138	0.058	0.02
Bill Frequency	-0.064	0.070	0.36	-0.062	0.071	0.38
Other Item(s) Billed	-0.013	0.064	0.83	-0.012	0.064	0.86
Own Electricity	0.030	0.047	0.52	0.030	0.047	0.53
Government Form	0.137	0.063	0.03	0.129	0.062	0.04
Sewer Use Ordinance	0.064	0.093	0.49	0.069	0.094	0.46
Pretreatment Ordinance	0.076	0.053	0.15	0.071	0.053	0.19
Mandatory Connection Ordinance	0.056	0.049	0.25	0.060	0.049	0.22
ln (Treatment Capacity)	-0.094	0.023	0.00	-0.101	0.026	0.00
Age of Sewer System	0.001	0.001	0.45	0.001	0.001	0.48
Own Facility	-0.201	0.065	0.00	-0.206	0.065	0.00
Infiltration & Inflow	0.137	0.062	0.03	0.138	0.061	0.03
Grease Reduction	-0.072	0.045	0.11	-0.070	0.044	0.11
Stormwater Management	0.173	0.058	0.00	0.166	0.058	0.00
Nutrient Removal	0.004	0.049	0.94	0.002	0.049	0.96
ln (Household Income)	0.120	0.114	0.29	0.123	0.112	0.27
Urban	0.008	0.046	0.86	0.003	0.046	0.96
Eastern Region	0.213	0.086	0.01	0.207	0.087	0.02
Southeastern Region	0.141	0.091	0.12	0.135	0.091	0.14
Northeastern Region	0.082	0.115	0.47	0.077	0.114	0.50
Piedmont Triad Region	0.135	0.095	0.15	0.130	0.095	0.17
Research Triangle Region	0.407	0.087	0.00	0.401	0.087	0.00
Charlotte Region	0.246	0.085	0.00	0.239	0.084	0.01
Year 2002	0.106	0.040	0.01	0.108	0.040	0.01
N		444			444	
F value		4.61			4.65	
Prob > F		0.000			0.000	
R^2		0.2556			0.2569	

[Table 6] Empirical Results: Monthly Wastewater Charges per KG (Residential, 100 KGs)

Dependent Variable: ln (Monthly Charges per 1,000 Gallons)	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value
Constant	0.408	1.786	0.82	0.247	1.783	0.89
ln (Sewer Accounts)	0.055	0.044	0.21			
ln (Household)				0.058	0.047	0.21
Decreasing	-0.060	0.075	0.42	-0.050	0.076	0.51
Increasing	0.211	0.113	0.06	0.214	0.115	0.06
Delivery Outside City	-0.024	0.115	0.84	-0.023	0.115	0.85
Rate Difference	-0.056	0.087	0.52	-0.054	0.087	0.54
Minimum Charge	0.212	0.086	0.01	0.218	0.087	0.01
Bill Frequency	0.042	0.082	0.61	0.052	0.084	0.53
Other Item(s) Billed	0.040	0.092	0.67	0.044	0.092	0.63
Own Electricity	0.034	0.063	0.59	0.035	0.062	0.57
Government Form	0.192	0.087	0.03	0.188	0.086	0.03
Sewer Use Ordinance	0.107	0.136	0.43	0.119	0.138	0.39
Pretreatment Ordinance	0.101	0.065	0.12	0.097	0.067	0.15
Mandatory Connection Ordinance	0.009	0.065	0.89	0.017	0.065	0.79
ln (Treatment Capacity)	-0.126	0.037	0.00	-0.130	0.041	0.00
Age of Sewer System	0.000	0.001	0.83	0.000	0.001	0.84
Own Facility	-0.221	0.086	0.01	-0.218	0.087	0.01
Infiltration & Inflow	0.139	0.077	0.07	0.143	0.076	0.06
Grease Reduction	-0.116	0.060	0.05	-0.112	0.059	0.06
Stormwater Management	0.189	0.078	0.02	0.178	0.077	0.02
Nutrient Removal	-0.001	0.066	0.99	-0.004	0.066	0.95
ln (Household Income)	0.038	0.175	0.83	0.052	0.173	0.76
Urban	0.002	0.059	0.98	-0.001	0.059	0.99
Eastern Region	0.186	0.113	0.10	0.175	0.115	0.13
Southeastern Region	0.136	0.108	0.21	0.127	0.108	0.24
Northeastern Region	0.069	0.151	0.65	0.062	0.151	0.68
Piedmont Triad Region	0.129	0.115	0.27	0.116	0.115	0.32
Research Triangle Region	0.502	0.108	0.00	0.491	0.109	0.00
Charlotte Region	0.304	0.108	0.01	0.288	0.105	0.01
Year 2002	0.134	0.053	0.01	0.140	0.053	0.01
N		444			444	
F value		3.91			4.04	
Prob > F		0.000			0.000	
R^2		0.2077			0.2081	

[Table 7] Empirical Results: Monthly Wastewater Charges per KG (Residential, 1,000 KGs)

Dependent Variable: ln (Monthly Charges per 1,000 Gallons)	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value	Coefficient	Heteroskedasticity-Consistent Std. Error	P-value
Constant	1.873	2.961	0.53	1.575	2.957	0.60
ln (Sewer Accounts)	0.110	0.075	0.15			
ln (Household)				0.098	0.081	0.23
Decreasing	-0.089	0.093	0.34	-0.070	0.094	0.46
Increasing	0.183	0.183	0.32	0.187	0.187	0.32
Delivery Outside City	-0.023	0.178	0.90	-0.018	0.180	0.92
Rate Difference	0.023	0.134	0.87	0.024	0.134	0.86
Minimum Charge	0.290	0.138	0.04	0.296	0.141	0.04
Bill Frequency	0.151	0.118	0.20	0.174	0.121	0.15
Other Item(s) Billed	0.142	0.141	0.31	0.151	0.142	0.29
Own Electricity	0.033	0.095	0.73	0.037	0.094	0.69
Government Form	0.258	0.131	0.05	0.259	0.127	0.04
Sewer Use Ordinance	0.161	0.215	0.45	0.183	0.218	0.40
Pretreatment Ordinance	0.110	0.086	0.20	0.107	0.090	0.23
Mandatory Connection Ordinance	-0.047	0.098	0.63	-0.033	0.100	0.74
ln (Treatment Capacity)	-0.180	0.062	0.00	-0.179	0.071	0.01
Age of Sewer System	-0.002	0.002	0.30	-0.002	0.002	0.31
Own Facility	-0.264	0.128	0.04	-0.250	0.129	0.05
Infiltration & Inflow	0.123	0.102	0.23	0.133	0.101	0.19
Grease Reduction	-0.167	0.089	0.06	-0.159	0.088	0.07
Stormwater Management	0.184	0.121	0.13	0.167	0.119	0.16
Nutrient Removal	-0.012	0.098	0.90	-0.016	0.097	0.87
ln (Household Income)	-0.122	0.292	0.68	-0.092	0.288	0.75
Urban	-0.021	0.084	0.80	-0.018	0.083	0.83
Eastern Region	0.123	0.164	0.46	0.105	0.170	0.54
Southeastern Region	0.155	0.136	0.25	0.143	0.137	0.30
Northeastern Region	0.039	0.210	0.86	0.031	0.212	0.88
Piedmont Triad Region	0.124	0.167	0.46	0.101	0.166	0.54
Research Triangle Region	0.594	0.148	0.00	0.578	0.148	0.00
Charlotte Region	0.363	0.149	0.02	0.334	0.142	0.02
Year 2002	0.189	0.075	0.01	0.200	0.078	0.01
N		444			444	
F value		2.74			2.87	
Prob > F		0.000			0.000	
R^2		0.1541			0.1522	