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Price Perception under Increasing Block Rates

— The Case of Residential Water Demand —

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Ⅰ. Introduction

Each Korean water utilities have used increasing block rates (IBR) schedule as a one of price policy instruments for the demand side management. Demand analysis under block rate schedule, however, is complicated, because there is still some uncertainty among resources

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economist concerning the proper specification of demand equations. Much of this uncertainty is focused on the question of the perception of price by the consumer: Do consumers react to marginal prices (*MP*) or average prices (*AP*)? (Nieswiadomy and Molina, 1991, p. 352)

According to economic theory, well-informed consumer facing block rates schedule responds to marginal price. However, there is little support for this assumption, because it is difficult to determine true marginal water prices and infra-marginal charges without information cost (the cost that is required to get true information). The information cost of determining true marginal may be occurred because of complicated nature of the block rates schedule and complex billing statements.

Define perceived price, P^*, as the price to which the consumer actually responds. If the expected marginal gain from the determination of true marginal price is greater than its marginal information cost, the consumer will determine the marginal price and perceived price will equal actual marginal price. However, if the expected marginal benefits are less than the expected marginal information costs, the consumer will likely react to some proxy marginal price, such as an *ex post*-calculated average price from a recent bill.

Reacting to average price rather than marginal price also means that the presence of rate structure premium (*RSP*) does affect water consumption significantly through its effect on price perception rather than effect on income variables (Shin, 1985, p. 596).[1] If the consumer stops searching for information when expected marginal benefit equals

1) $AP = E/Q = MP + RSP/Q$, E = monthly bill and Q = monthly consumption, See, Shin (1985), p. 593, for detail.

expected marginal information cost, perceived price may lie between marginal and average price.

Opaluch (1982) was the first to devise a test of whether consumers respond to marginal or average price in their demand for water. However, the test does not permit the consumer to react to a function of both marginal and average prices (Nieswiadomy and Molina, 1991, p. 352). Shin (1985) presented a model that permits a price perception parameter to be estimated explicitly and determined whether consumers react to marginal price or not. Shin (1985) determined, through empirical analysis, that consumers in the United States apparently react to average price rather than marginal price when faced with a decreasing block structure for electricity.

Subsequently, Nieswiadomy and Molina (1991) used the same approach to water consumption in city of Denton, Texas. They concluded that consumers are responding to the average price more closely when faced with a decreasing block structure; however, for increasing block data indicate that water consumers are more likely to react to the marginal price under IBRs. Nieswiadomy (1992) also used same approach to 430 aggregate demand data of U.S. utilities.

In this paper, we analyze price perception behavior under IBR of Korea. We use household data set on water consumption of city of Seoul in Korea. It may be the first approach in Korea using microeconomic data to analyze price effect on residential water demand. Empirical results of price perception in Seoul will be helpful for water utilities want to promote efficient water use. From this analysis, we also identify the sciodemographic variables that determine residential water demand.

The paper is organized as follows. Section II presents the model specification and describes data set. Section Ⅲ examines the results of estimation. Section Ⅳ contains conclusion.

Ⅱ. Model Specification and Data Set

To analyze consumer price perception behavior empirically, Shin (1985) suggest that we construct price perception variable as a function of the marginal price, the average price, and price perception parameter, k, as follows:

$$P^* = MP(AP/MP)^k \tag{1}$$

If the consumer responds only to MP, then $k=0$. If the consumer responds only to AP, then $k=1$. If the consumer's perceived price lies between AP and MP then $0<k<1$. If k is greater than one or less than zero, it has different interpretations depending on whether $AP>MP$ or not. In the case of $AP>MP$, if k is greater than 1 it implies $P^*>AP>MP$ and if k is less than zero, it means $P^*<MP<AP$. However, in the case of $AP<MP$, if k is greater than 1 it implies $P^*<AP<MP$ and if k is less than zero, it means $P^*>MP>AP$ (Nieswiadomy and Molina, 1991, p. 353).

In the other aspect, when $P^*<(>)MP$, if consumer can determine true marginal price with zero information cost, the consumer could increase his utilities by decreasing (increasing) his consumption. These have other important policy implication: when $P^*<(>)MP$, increased information on water use, e.g., government water conservation pamphlets, has (no) positive effects on water conservation (Shin, 1985, p. 598).

To analyze the water demand under IBR of Korea, we use microeconomic data set on water consumption of city of Seoul. The data used are from a survey of 240 households in Seoul, sampled randomly, which was carried out in October of 1998. The survey data were consists of billing period, water use in that period, and sciodemograhic characteristics data. We restrict our data set to the household have detached (individual) household water meters. We collect the water use data from April of 1997 to August of 1998. We used this water usage data as pooled cross-section, time-series of monthly; we used totally 710 data sets. In <Table 1>, the rate schedule of Seoul is described. <Table 2> describes the definition of variables, and some summary statistics of the data set are given in <Table 3>.

The fixed charges and price variables are deflated by consumer price index (1995 = 100). The variable *DETACH1* is constructed to represent the difference in water usage between those living in detached house and those living in the other residences. In non-detached house (e.g., apartments), there are common water usage because facilities are shared. In these cases, common usage is not metered by detached household water meters. Accordingly, we expect that compared with data from detached households' water meters, the water usage for those living in non-detached dwellings is relatively less. In case of Seoul, renters in detached houses are commonly dwelling in part of a house; thus, we expect that renters' water usage is less that of the house owner. The *DETACH2* variable reflects this difference. Weather data are constructed by using temperature (℃) of Seoul during the sample periods. The

〈Table 1〉 The Water Rate Schedule of Seoul

Period	~ 10 / 1997			
		Rate (nominal won)		
	Block(m^3/month)	Water	Sewage	Summary
Rates Structure	0 < ~10	0	0	0
	10 < ~15	180	0	180
	15 < ~20	180	60	240
	20 < ~30	220	60	280
	30 < ~40	460	165	625
	40 < ~50	540	165	705
	50 +	770	330	1100
Number Of Observations	60			
Period	11 / 1997 ~ 8 / 1998			
		Rate (nominal won)		
	Block(m^3/month)	Water	Sewage	Summary
Rates Structure	0 < ~10	190	0	190
	10 < ~15	240	0	240
	15 < ~20	240	60	300
	20 < ~30	270	60	330
	30 < ~40	460	165	625
	40 < ~50	540	165	705
	50 +	770	330	1100
Number Of Observations	650			

LAWN2 variable is used in our estimation instead of *LAWN1* variable because for the non-detached dwelling the lawn is the generally common or shared area.

〈Table 2〉 Definition of Variables

	Definition
WATER(m^3)	Monthly water consumption
MP(won)	Marginal Price
AP(won)	Average Price
INCOME (10 thousand won)	Monthly Income
RESIDENTS	Number of Residents in Household
OWNERSHIP	Dummy variable, 1, residents are house owner 0, otherwise
DETACH1	Dummy variable, 1, dwelling is detached house 0, otherwise
DETACH2	Dummy variable, 1, OWNERSHIP=1 & DETACH1=1 0, otherwise
LAWN1	dummy variable, 1, there is lawn in house 0, otherwise
LAWN2	Dummy variable, 1, DETACH2=1 & LAWN1=1 0, otherwise
CONSYR	Construction Year of House - 1900
TEMPER(℃)	Weather Variable, Temperature
NOBATH	Number of Bathrooms

notes : MP = Water Rate+ Sewage Rate at block for demand quantity.

$$AP = E/Q = (MP_k(Q - Q_{k-1}) + MP_i(Q_i - Q_{i-1}) + \sum_{i=0}^{k-1} FC)/Q$$

$$\text{if} \quad Q_{k-1} \leq Q < Q_k$$

where Q is demand quantity

MP_i is marginal price of water at block i

Q_i is the upper bound of the ith block and the lower bound of the $i+1$th block, FC is fixed charge

$Q_0 = 0$

〈Table 3〉 Summary of Statistics

	Mean	Standard Deviation	Minimum	Maximum
WATER	22.06854	8.6804	5.5	60
MP(real won)	298.3941	132.5533	162.2545	1007.326
AP(real won)	262.4562	38.15847	184.1386	478.2795
RESIDENTS	3.7619	0.7788	2	7
DETACH2	0.17316	0.37866	0	1
LAWN2	0.05772	0.23338	0	1
NOBATH	1.10823	0.33763	0	2
CONSYR	88.56566	6.9528	70	97
TEMPER	11.39841	8.38863	-1.3	26.8
INCOME	205.1343	64.41963	67.32031	471.24216

Ⅲ. Estimation Results

The model including equation (2) is specified as follows.

$$\begin{aligned}\ln(WATER) &= \alpha_0 + \alpha_1 \ln(INCOME) + \alpha_2 \ln(MP) \\ &\quad + \alpha_2 k \ln(AP/MP) + \delta Z\end{aligned} \tag{2}$$

Where, Z represents sociodemograhpic variables and, α and δ are the unknown parameters.

It is generally accepted that Ordinary Least Squares (OLS) estimates of functions for consumers facing block rate schedules will yield biased estimates, since the price variable is correlated with the random error term through on its dependence on demand quantity (the marginal price and average price are determined according to demand level). While several instrumental variable techniques (IV) have been suggested, we focus on one commonly used one, which is originally due to McFadden, Puig and Kirschner (1977). In this technique, observed consumption is regressed on the sociodemographic variables, the marginal prices associated with each blocks as well as the fixed charges, and income in the first stage estimation. The predicted consumption from this regression determines the marginal price and average/marginal price instrument to be used in second stage estimation.

Hausman's (1978) specification test was performed to check for simultaneity bias. The calculated Hausman's test statistics is 51.457, which exceeds the critical value of chi-square at the 1 percent level of significance, for ten (number of explanatory variables) degrees of freedom. OLS estimates in this study illustrate the bias in these estimates.

The model estimates are reported in <Table 4>.[2] The estimated coefficient of *MP*, *AP*/*MP* and almost sciodemographic variables are significant and have the expected signs in IV estimation.

The main point is the value of the degree of price perception that is measured by the estimate of k, 1.1179. The null hypothesis of $k=0$ is rejected with t statistics of 3.4720, whereas the null hypothesis of $k=1$ is accepted (cannot be rejected) with t statistics of 0.3661 at 1% and 5%

2) The present study uses the average price of the current year rather than that of the previous month (Shin, 1985) since we cannot always get the usage data that is continued in adjacent month. Because, we use log specification for price variable, we exclude the data of which marginal price is zero, so, total number of data are 693.

〈Table 4〉 Estimation Results

	MODEL	
	OLS	IV
Constant	-0.2717(0.5621)	5.9534(4.2289)**
ln(INCOME)	0.0554(2.5285)*	0.0928(2.0747)*
ln(*MP*)	0.4812(9.2056)**	-0.5338(-2.5550)*
ln(*AP*/*MP*)	-0.6301(-10.0703)**	-0.5967(-3.4586)**
ln(RESIDENTS)	0.1477(4.7123)**	0.3164(4.7479)**
DETACH2	0.0864(3.9652)**	0.2028(4.3393)**
LAWN2	-0.0284(-0.8361)	0.1091(1.5533)
ln(CONSYR)	0.0016(0.0188)	-0.2545(-1.4777)
TEMPER	0.0003(0.3116)	0.0059(3.5309)**
NOBATH	0.0251(1.2222)	0.1251(2.7828)**
k	-1.3093(-4.9135)**	1.1179(3.4720)**

Notes : The number in parentheses are the t-ratio.
* significant at 5% level, ** significant at 1% level.

level. Hence, it appears that the consumers are responding to average price rather than marginal price in the case of water demand under IBR in Seoul. The parameter estimate can be regarded as evidence that the presence of rate structure premium (RSP) does affect water consumption significantly through its effect on price perception.

We conjecture that the one of reason of this perception behavior is the complexity of IBR scheme for water demand in Seoul. It is divided to two schemes for water and sewer, each scheme has different lower and upper bound on each block, and scheme for water has rather many blocks.

The above results can be compared with the results of Nieswiadomy and Molina's (1991), the case of water demand under decreasing block rates and IBR in city of Denton, Texas. It appears that the consumers were more likely responding to average price rather than the marginal price for the decreasing block rates, whereas for the increasing block rate structure, it appears that the consumers are responding to marginal price in Nieswiadomy and Molina's (1991). It shows that there might be different price perception behavior under same increasing block rate.

The estimate of price elasticity in IV is -0.5338 and the income elasticity is 0.0928. The number of residents, temperature and number of bathroom are significant in IV estimation, indicating these variables are an important determinant of residential water demand. The estimate of *DETACH2* variable is also positive and significant.

IV. Conclusion

Because of complicated nature of the block rates schedule and complex billing statements, there is some uncertainty concerning the perception of price by the water consumer. In this paper, we analyze price perception behavior under IBR of Korea using Shin's (1985) approach. We use microeconomic data set on water consumption of city of Seoul. We use OLS and IV estimation approaches, and the result of Hausman's (1978) specification test shows the simultaneity bias of OLS estimation under block rates. IV estimation results in this study show that the consumers are responding to average price rather than marginal price in the case of Seoul ($P^* = AP$).

These results have other important policy implication about the effect of increased information. Because $P^* = AP$ and sample data of this study shows that share of the case when $MP > AP$(78%) is higher than share of the case when $MP < AP$ (22%), the increased information on water use pattern e.g. education or campaign for water conservation, can have positive effect on water conservation of more households ($P^* = AP < MP$).

The number of residents, temperature and number of bathroom are significant in IV estimation, indicating these variables are an important determinant of residential water demand.

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ABSTRACT

누진요금제도에서의 가격 인식: 가정용 상수도 수요 분석

김연배 · 김태유

누진요금에서의 수요행위는 그 복잡성으로 인해 많은 논의를 불러 왔다. 그러한 논의 중 주요한 하나는 과연 소비자들이 한계가격에 반응하는가 아니면 평균가격에 반응하는가이다. 본 연구에서 우리는 서울시 가정용 상수도 수요 자료를 사용하여 체증 누진요금에서의 가격인식 행동을 분석하였다. Shin (1985)의 방법론이 분석을 위하여 사용되었으며, 내생성 문제를 해결하기 위해 도구변수 추정법이 사용되었다. 분석 결과 서울의 경우에는 소비자들이 한계가격보다는 평균가격에 반응함을 알 수 있었다.