Water demand and the urban poor: A study on the conditions for water consumption on the Cape Flats, South Africa

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Abstract:

Water demand management is a key focus area for most water managers, and even more in the developing countries. Improved access to water is important to the poor. Water scarcity makes efficient management even more urgent, and it creates more conflicts on water distribution. Different policies have been introduced to ensure a water management system that cares for the poor, among them the Increasing Block tariff (IBT) system. Studies demonstrate that it is very important to know the shape of the demand curve when deciding on the IBT system. This is particularly so when it comes to supply to the poor. The purpose of this paper is to provide a greater understanding of the factors that influence water consumption. It also aims at providing an estimate for the price elasticity of water demand on the Cape Flats, in the Western Cape Province, South Africa. The study utilizes household data that covers a period of up to 60 months starting from July 1998 to June 2003. The water consumption data was obtained from the local government, the City of Cape Town and a survey study in five suburbs in the area.

Based on household data for a period of 60 months, a panel data analysis, utilizing the random effects model, demonstrates how different factors explain the water consumption, among them the price of water. We find that the consumption is less sensitive to price changes among the poor, while the richest group of households react more to price changes. The results seem to be quite sensitive to changes in the model specification. OLS estimation does not address the simultaneity in the data, and splitting the data into different suburbs and income groups is also important. The relatively inelastic demand for water implies that rather substantial increases in price would be required to change water consumption patterns in the short run, and it will only work for the high income groups. The results may add to the knowledge needed to improve the IBT structure to achieve greater equity.

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1 Introduction

The pricing of water is an important issue in developing countries. Water is important for development, and usually poor people cannot afford the costs of water. Improved management of water distribution is therefore an important development issue. In rural areas water is supplied in different ways, not always tapped, and often not metered. This is particularly so for the low income and poor groups. Even in urban areas poor people will often collect unmetered water, but tapped water is more dominant than in the rural areas. Water is metered for many residential consumers in urban areas, and if so also pricing policy can be used to manage water distribution. Water has become increasingly scarce due to factors like population growth, economic growth, increased urbanization and changing climatic patterns. This faces water managers with the problem of providing water in an efficient and just way. South Africa is no exception to this situation. Even in informal settlements many households pay for their water, and low income groups have metered connections. This way the pricing of water is part of a management system to distribute water. Payment for water is part of the funding of the water service. But it is also one way of regulating the consumption of water. However, pricing can only regulate consumption if the households react to price changes. This study will try to add to the knowledge of how different groups react to water pricing.

There are different options for handling the scarcity problem. Increased supply, including exploring the building of new dams and other infrastructure, is one way out. . More recently, the attention has turned to water demand side management. Winpenny (1994) states that projects to increase water supply face hydrological limits, rising costs in terms of pumping and transferring water over long distances, and also increasing environmental costs to which society is more sensitive. For economic efficiency reasons they must be traded off against the willingness to pay for water in some way or another. For these reasons, water demand studies are needed. Stephenson (1999) argues that water consumption can be curtailed using physical, sociological and economic instruments. In the case of the latter instruments, it makes sense to organise water tariffs in a way that combines low price basic supply with a marginal price to curtail total consumption. In South Africa the town of Hermanus in the Western Cape Province is one of the few examples that instituted a comprehensive demand management campaign. Demand management can use a combination of quantitative restrictions and a tariff policy. If increased price reduces water consumption this may be an efficient way of managing water. Water managers therefore need information on how price changes impact on the demand for water.

This paper concentrates on urban residential water supply. In urban areas tapped water is more accessible, but still expensive for the poor. One way of handling this situation is to supply water to the poor at a lower price than to the more well off households. One way to do this is to introduce an Increasing Block Tariff (IBT), where the marginal price increases with consumption. This will support equity, and Moilanen and Schulz (2002) show how an increasing block tariff (IBT) can be used to support income redistribution. They also show, in a theoretical paper, that differences in the demand structure between rich and poor consumers are important when modeling the IBT. If the rich segment of the market is more sensitive to price changes, this information can be used to streamline the IBT structure for equity purposes. Other studies from developing countries include Rietveld et al. (1997), who study urban water demand in Indonesia, Gunatilake, et. al. (2001), who provide a study from Sri Lanka, and Strand and Walker (2003), who give results for water demand from different urban areas in Latin America.

If an increasing block tariff can be used for equity purposes, there is a real need for more knowledge of the demand structure. This need is the focus of this paper.

Many studies have been done on water demand, also on residential consumption. The results are mixed on the empirical side. A general overview, a meta analysis can be found in Dalhuisen et al (2003). Here, an analysis of variation is applied to the different price and income elasticities, as found in various studies. However, very few studies have utilized household data, and even less from developing countries. In South Africa, Veck and Bill (2000) applied a contingent valuation method to estimate the price elasticity of demand. Vuuren, et. al (2004) extended this analysis, and they estimate the response to price shifts based on questions to the households about how they will react in case of a hypothetical price change. As long as metered water is sold it is more appropriate to study real changes in prices and quantities and there is no need to use a contingent valuation study. A market study reflects real choices. This makes the estimates better and more reliable, since the analysis is based on observed consumption and not hypothetical scenarios.

The Plan for this Paper

In the next section a literature review provides the background to the empirical study in this paper. It specifically highlights the factors that need to be considered in estimating residential water demand and also elaborates on the estimation techniques that are most common in recent water demand studies done internationally. Section 3 provides an overview of the water resource situation in the Cape Metropolitan Area (CMA). Section 4 discusses the factors that influence water demand, while section 5 focuses on the data collection process as well as the methodology applied in this particular study. This is followed by section 6, which discusses the results. Section 7 concludes with some findings and recommendations for water management policy.

2 Background from other Water Demand Studies

The importance of managing water resources, especially giving due consideration to the demand side management, has been emphasized by the number of studies investigating the estimation of residential water demand. The intention here is to provide a short overview of some of these studies, with particular emphasis on those most relevant to the nature of this study. Key aspects such as which variables to include in the estimation of water demand as well as the way to model it will be highlighted, the relevance of which will be incorporated in subsequent sections.

One of the key outcomes in most water demand studies is related to the price elasticity of demand for water. Whether demand is elastic or inelastic will tell us something about the responsiveness of consumption to changes in the price of water. According to Martínez-Espiñeira & Nauges (2003), one should view the demand curve for water as consisting of both elastic and inelastic parts. They base their empirical analysis on a demand curve where the theoretical foundation is the Stone-Geary utility function. In this framework, the consumption of a commodity is divided into a fixed quantity that is unresponsive to price changes immediately and a residual component that can adjust to price changes instantaneously. The results from this study provide water managers with important information about the threshold of the quantity of water below which consumption will not respond to price changes, assuming that the household environment remains the same.

When estimating water demand with an increasing block tariff structure, it is necessary to take account of the subsidy associated with this type of pricing structure. Jones & Morris (1984) refers to this as the inframarginal rate, which is the difference between the consumer's bill and the cost of the full quantity purchased all valued at the marginal price. In most instances, researchers opt to model the demand function including both marginal price and a difference variable, where the latter is included to capture the effects of changes in the inframarginal rate (Barkatullah, 2002).

Another issue that needs attention when modeling water demand is the problem of simultaneity. According to Wooldridge (2003), simultaneity arises when one or more of the explanatory variables are jointly determined with the dependent variable. Nieswiadomy & Molina (1989) argue that, in the case of block pricing, the marginal price determines and is also determined by, consumption. Due to the increasing block tariff structure (IBT), high consumption is always observed linked to a high marginal price of water. To correct for this, we must use other statistical techniques, as demonstrated by Nieswiadomy & Molina (1989), Barkatullah (2002), and others. In our case, using OLS as an estimation technique will produce biased and inconsistent results.

Barkatullah (2002) used a panel data set, at the household level, to estimate a mixed-effects residential demand model for Sydney, Australia. The mixed-effects model is specified to account for both random and fixed effects. The model is estimated through the maximum likelihood technique. The econometric model also addresses the problem of simultaneity by using an instrumental variable technique. The variables included in the demand equation consist of climatic variables, the marginal price faced by households, demographic variables on the household and income. Another variable included here, which is frequently used in other demand studies as well, is what they call a 'difference' variable, trying to include the difference between the marginal and the average price for water. Barkutullah (2002) finds that the Instrumental Variable / Maximum Likelihood estimations provide a marginal price elasticity coefficient of -0.21, indicating an inelastic water demand. Other variables also display the 'correct signs' (i.e. negative demand elasticity), for example household demographics such as the number of bedrooms and baths and household size. She also estimates the model using OLS, but finds that the marginal price elasticity coefficient is positive, indicative of the bias associated with the problem of simultaneity. Her estimates are shown to be highly sensitive to her estimation methods.

Höglund (1999) estimated the Swedish household water demand using a panel data set of 282 communities. She indicates that one could question the usage of data at the community level since the variation of household behaviour within these communities is removed. However, due to lack of detailed data, she utilizes aggregate data at the community level. Estimation involved two types of models, static and dynamic, where the latter specifically accounts for the fact that adjustments to changes in consumption take time, especially when the cost of water is a small proportion of household expenditure. She finds that the parameter estimates for the dynamic models are quite close to those of the static models such that the estimates for the former can provide an approximation of the long-run estimates. Höglund (1999) also finds that consumers react to both marginal prices and average prices. However, these two prices are closely interrelated.

Starting from existing literature, there is a noticeable lack of household studies, and there is also a very strong bias to study water demand among the relatively rich households. In South Africa, although some studies have been conducted especially trying to model the behaviour of the lower income groups (see above), no econometric analysis based on metered consumption has been applied. One particular study conducted at the micro level in developing countries is the one on household demand for water estimated in Sri Lanka. Gunatilake, et. al. (2001) estimated the demand for water using household data. Their sample consisted of 40 households, and they made use of a panel set from 1994 to 1999. Their demand equation included household income and size, the information for which they collected by means of a survey. Their results reflect that demand for water is price inelastic and income inelastic. Thus, they conclude that water is not very price responsive and that price increases may not help to conserve water. A similar and very interesting study is Strand and Walker (2003) who studies water consumption in different Central American cities based on household data.

Many international studies use aggregate data and household studies are almost all in rich areas. We want to add to this – with household studies among the relatively low income groups employing econometric analysis. For this purpose, the Cape Flats (in the CMA) provides good data. The water is metered, even in areas of low income groups. It therefore seems possible to provide an adequate sample area within which to conduct this study.

3 A short overview of the water resource situation in the CMA

The Western Cape is a region of water scarcity; the average annual rainfall is only 515 mm. Most rainfall is during winter, while the period October-March is the dry (and hot) season. For each dry season the municipality (City of Cape Town, CCT) may implement water restrictions aiming for up to 30% reduction of the consumption. Since 1997 the CCT uses an increasing block tariff (IBT) structure for water pricing. More recently it implemented the national policy of a free provision of basic services, allowing for 6 kilolitres of free water per metered household. According to this policy, the setting of tariffs must ensure both the free water as well as a financially sustainable water supply for the municipality (PDG, 2001), with a budget for the water service set by the CCT. Table 1 gives the pricing structure as applied by the CCT:

Table 1: DOMESTIC WATER CONSUMPTION TARIFFS[1]: CITY OF CAPE TOWN

Tariff Change Date			01-Jul-98		01-Jul-99		01-Jul-00		01-Nov-00
Consumer Category	Step	kl	2000/2001	kl	1999/2000	kl	2000/2001	kl	2000/2001
Domestic Full	Step 1	0-30	R 1.05	0-5	R 0.50	0-6	R 1.09	0-6	R 1.09
	Step 2	31-150	R 2.22	6-15	R 1.60	7-15	R 1.86	7-15	R 1.95
	Step 3	150+	R 3.65	16-30	R 2.70	16-30	R 2.91	16-30	R 3.06
	Step 4			31-50	R 3.80	31-50	R 4.40	31-60	R 4.62
	Step 5			50+	R 5.00	50+	R 6.00	60+	R 6.30
	Step 6								
Tariff Change Date			01-May-01		01-Jul-01		01-Jul-02		01-Jul-03
Consumer Category	Step	kl	2000/2001	kl	2001/2002	kl	2002/2003	kl	2002/2003
Domestic Full	Step 1	0-6	R 0.00	0-6	R 0.00	0-6	R 0.00	0-6	R 0.00
	Step 2	7-15	R 1.95	7-20	R 2.60	7-20	R 2.73	7-12	R 2.00
	Step 3	16-30	R 3.06	21-40	R 4.10	21-40	R 4.30	13-20	R 4.00
	Step 4	31-60	R 4.62	41-60	R 5.20	41-60	R 5.40	21-40	R 5.10
	Step 5	60+	R 6.30	61+	R 7.00	61+	R 7.35	41-60	R 6.20
	Step 6							61+	R 8.00

Source: Water Services Department, CCT, 2004

[1] The tariffs are in nominal prices. For the econometric analysis, these tariffs are converted to 2003 prices.

The IBT structure reflects the CCT's efforts to reduce water consumption by using quite steep tariff steps in the upper end.

4 Factors influencing Water Demand

Water demand is based on the behaviour of consumers, and for this study we concentrate on households. Water is part of the bundle of goods that adds to human well-being. Hence we can use the mainstream approach of demand studies to understand the factors influencing water demand. We want to study the structure of the water demand, trying to find the variables that influence the demand, and the importance of each.

Pricing

Usually economic theory suggests that the consumers react on the marginal price of the product. This is not obvious for a situation with both access fees and an IBT. For instance, Gracia, et. al. (2001) argue that most consumers are not sufficiently informed about the rate structure to react to marginal prices, but do state that this will be determined by empirical investigation into modeling water demand.

If the marginal price differs from the average price there exists an implicit lump sum transfer linked to the purchase of water. To include this in the analysis we, as many other studies, will use the Taylor-Nordin difference variable – in some studies named the Rate Structure Premium (RSP).[2] Chicoine & Ramamurthy (1986) state that the RSP represents the income effect entrenched in the IBT. They argue that if there is perfect information, then utility-maximizing households will respond to the marginal price and the difference variable. We use the marginal price and the RSP in this study.

[2] According to Barkatullah (2002), the difference variable (RSP) is the second 'price' variable introduced by Taylor in 1975 and further developed by Nordin in 1976. The RSP is the difference between the actual water bill and what the bill would have been had consumers paid for full consumption at the marginal price. In the case of an increasing block tariff, the RSP is expected to be either 0 or negative. This implies that the RSP in our case can be seen as an implicit income subsidy. We distinguish this from income because both we and the consumers will see this as a subsidy linked to the actual water consumption.

Income

Income is a main determinant of consumption. Renwick & Green (1999) use median household income for each of the water agencies included in the study, Barkatullah (2002) uses income and property values obtained from a survey conducted in 1992 as indicators of the budget available for households. Höglund (1999) includes the average gross household income in her study. Gunatilake, et. al. (2001) use household income data from a survey. Renzetti (2002) reports on a study by Hanemann (1998) which lists price and income elasticities, and reflects that most income elasticities are positive but income inelastic. The average income elasticity is around 0.52.

Weather Variables

It is reasonable to guess that weather patterns will influence the consumption of water, like more water consumed in hot weather, and less during rainy periods. Howe and Linaweaver (1967) estimated a sprinkling demand model where they specifically take into account summer precipitation and maximum day evapotranspiration. Renwick & Green (1999) also include seasons and climate.

Household Demographics and other Characteristics

Individual differences in the households definitively influence their water demand. Household size is probably important, (Nieswiadomy & Molina, 1989), as well as the age structure of the household. Other variables, like the house size and appliances (showers, bathrooms, washing machines, etc.) are also relevant (Barkatullah (2002), Renzetti (2002)). Public information campaigns, the supply of water saving technology etc., may also influence water consumption at the household level. A main distinction in water consumption is between indoor and outdoor use. This specification can also care for some of the split between basic use and more additional use of water (pools, lawns, carwash etc.)

In this study, we include as explanatory variables different household characteristics, as well as an age variable for the household.

5 Data Collection and Methodology

5.1 Data Collection

When studying water demand we want to estimate the influence of different factors. However, we do not aim to estimate the water consumption of some specific area (like the Cape Town Metropolitan area). Hence, we do not care for a representative sample, but rather a sample that includes enough variation in the potential explanative factors. First, we need diversity among the households we study. The informal settlements and the ultra poor constitute one part of the market. However, they get their water supply from communal standpipes or other unmetered sources. Hence, measuring their consumption can only be done by on spot observation and measurement inside each household[3]. In our study we exclude the segment without metered water. To include possible differences in water consumption between different cultures and income groups we select observations from two historically black suburbs, two historically coloured suburbs, and one historically white suburb, in the CMA. All of them are inside the same municipality (The City of Cape Town, CCT) during the period of our study. Households have been selected at random inside each suburb[4]. It is therefore possible that our sample is not representative. However, this is a minor problem as long as we want to estimate the consumption patterns of households and not of the area as such. Each household had to give their signed permission to obtain monthly readings of their water consumption from CCT. This makes the date more reliable, since data collectors must definitely have visited all the households included in the study. All household information were collected by use of a questionnaire, and later matched with monthly readings from CCT for the period 1998-2003. We used mainly students in Economics at the University of the Western Cape to collect the household data. The advantage of this is that data collectors knew the area, the language and the culture of each suburb. For Guguletu we employed assistants from the suburb itself to bridge the gap to the residents. In Pinelands (the richest suburb) we had a problem of access, since we usually needed an appointment beforehand.

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[3] These households do not pay for water, and so their consumption cannot be influenced by price changes. One can give an estimate of their consumption by using observations of poor households inside the zero-price segment of the metered water supply. However, these households have potable water inside their house, and they are not comparable to households who must bring water from a standpipe.

[4] For certain suburbs, some areas were not easily accessible. The data collection process had to maintain a safe process for the data collectors.

The data

The water consumption data covers the period from July 1998 to June 2003, up to 60 observations per household. However, for some household we only have shorter time series due to the fact that meters were installed only later during the specified period. We had to exclude some households due to mismatching or incomplete records with the CCT, and 275 households are left in our final sample. Table 2 gives an overview of the data set.

Table 2: Distribution of Household Size and Household Age by Suburbs

Suburb	Number of Households	Distribution of Household Age				
		No. of Babies (0-3 yrs)	No. of Children (4-11 yrs)	No. of Teenagers (12-18 years)	No. of Adults (19-60 yrs)	No. of Elderly (61 yrs +)
Guguletu	64	13	53	43	209	66
Kensington	53	7	17	29	169	40
Langa	49	16	31	42	139	25
Mitchell's Plain	73	19	55	63	228	28
Pinelands	36	1	7	15	78	20
TOTAL	275	56	163	206	914	199

Source: Own Calculations (2005)

The cross-section data was collected during July – August 2003. To make a panel data set, the survey data is combined with the water consumption data from the CCT[5]. The data set also includes average monthly rainfall and average monthly maximum and minimum temperatures for the City of Cape Town[6].

[5] The data set includes time series for water consumption, water tariffs, climate and household structure, as well as others, like household size, income, plot size and other demographic variables and appliances etc., on the household. The descriptive statistics in table 3 support our assumption that income and household size did not change significantly during the period under investigation.

[6] The weather variables were obtained from the South African Weather services, observations made at the Cape Town International Airport.

Descriptive Statistics

The table below provides some descriptive analysis of the household data obtained from the survey.

Table 3: A DESCRIPTIVE STATISTICS OF HOUSEHOLD DATA

Category	Description
Type of Accommodation	99% of households reside in a house
Ownership of Dwelling	97 % of households own the dwelling
Metered water for the household	100% of the sample has metered water in their dwelling.
Access to Borehole	Less than 1% of the households have access to a borehole.
Significant changes in the size of the household over last 2 years.	14% of the households indicated a change over the last 2 years, (7.3% indicated a decrease and 6.6% indicated an increase).
No. of Babies (0-3 years)	56
No. of Children (4-11 years)	163
No. of Teenagers (12-18 years)	189
No. of Adults (19-60 years)	819
No. of Elderly (61 years +)	178
Showers/ baths	Bath: 39%, Both a shower and a bath: 37%. None of these: 22%.
Dishwasher	Less than 10% of households own a dishwasher.
Washing Machine	70% of households (70%) own a washing machine.
Car	45% of the households own a car.
Swimming Pool Geyser in the house	9.5% of households own a swimming pool. > 60% of households have a geyser.
Garden	49% of the sample (49%) has a garden.
Awareness of water restrictions	78% aware of water restrictions.
In-door water saving methods	94% indicated checking of dripping taps as for water saving
Out-door water saving methods	45% indicated paving part of outside area as way of saving water
Knowledge of water tariffs	29% indicated knowledge of the water tariffs.
Reaction to water tariff changes	64% indicated that they do not change their consumption when the tariffs change.
Ease to change water consumption	70% indicated difficulty to change water consumption.
Reasonable to pay for water	77% felt that it was reasonable to pay for water.
Reasonable to cut off water for non-payment	> 60% felt that it was not reasonable to cut off water for non-payment of bills.
Income: 0 - R1000 per month	29%

Income: R1001 – R5000 per month	39%
Income: R5001 – R10000 per month	18%
Income: R10001 – R20000 per month	7%
Income: > R20000	7%
Significant changes in income over the last 2 years	25% indicated a change over the last 2 years, (18% indicated a decrease and 7% indicated an increase).

Source: Own calculations (2005)

The table highlights some important characteristics about the data set used in this study. In most cases the research team dealt with households who owned the houses they occupied and all these have metered water. From the survey information, most households indicated very little change in the size of the household and their incomes. Although the latter may be under doubt, given this information, we make the assumption that the household size and the income are constant over the study period. This also applies to the plot size. What is also interesting is that the many of the households own a washing machine and that almost half of them own a car. From the income categorical variables, however, the greater proportion falls in the income brackets below R5 000 per month. The distribution of households by income category is provided in the table below:

Table 4: Distribution of Households by Income Category

Suburb	<1000	1001-5000	5001-10000	10001-20000	>20000	TOTAL
Guguletu	39	24	1	0	0	64
Kensington	4	17	22	7	3	53
Langa	20	26	3	0	0	49
Mitchell's Plain	18	39	12	4	0	73
Pinelands	0	1	11	8	16	36
TOTAL	81	107	49	19	19	275

Source: Water Survey data (2003)

Table 4 shows that most households in Guguletu (98%), Langa (93%), and Mitchell's Plain (78%) fall within the lowest two income categories (Y_0 and Y_1). This is a much higher proportion than in Kensington (39%) and Pinelands (2.7%). At the other extreme, only Pinelands and Kensington have households recorded in the highest income category of Y_4, 44% and 5.6% respectively.

5.2 Methodology

5.2.1 Panel Data Analysis

Our approach to the econometric analysis is to use a Panel data analysis. The reason for this is that the data is a mix of cross sectional data (275 households); for each household we have records for up to 60 months of water consumption. We also have monthly information on climate. In total our data is an unbalanced panel, mixing cross-sectional information with time records, with the length of time periods differing between households. A panel data analysis can include this information into our study, while a pooled approach (using each monthly observation as it is) will miss out on this. In the choice between a fixed effects or a random approach, we will argue that a fixed effects approach misses out on important information. The reason is that in the fixed effects approach we include all household differences in the constant term, and we analyse differences within each household over the time period. Since we know that most households have been quite stable during the period, the changes in water consumption must be small during the period, and we miss crucial information in quantity/price variation by use of this technique. Our choice is to use a random effects model, where the difference between the households is modeled as a random variable. We will, however, compare our estimates with other possible approaches (specifically the pooled regression).

The data set in this paper combines variables that change over the 5 year period under investigation (e.g. the price of water, climate variables and some characteristics of the household such as average age), with some time invariant variables that explain the household such as plot size, household size, and some dummies such as baths, gardens, washing machines and income data gathered only once.

Following Greene (2003), we start off with a basic model as follows:

$$Y_{it} = X_{it}'\beta + Z_i'\alpha + \varepsilon_{it} \qquad i = 1\ldots..275,\ t = 1\ldots..60$$

Where Y_{it} = dependent variable

X_{it} = vector of independent variables

Z_i = contains a constant term and a set of household specific variables

In the case of a pooled regression, Z_i contains only a constant term. In the panel study the random effects model assumes that we include a household-specific random term $Zi'\alpha = \alpha + u_i$, , which means that we assume that the unobserved individual heterogeneity is random, but not correlated to the explanatory variables (Greene, 2003). The model can then be specified as follows:

$$Y_{it} = X_{it}'\beta + \alpha + u_i + \varepsilon_{it}$$

u_i is a group specific random element that, for each group, enters the regression identically in each period (Greene, 2003, 285). We use this model (and the IV method – see discussion below) to estimate the parameters.

5.2.2 The IV technique

Throughout the models applied, we use instrumental variables (IV), to care for the biased results we encounter when estimating demand in a situation with increasing marginal price (the IBT structure). The specific IV approach adopted is discussed below.

We use the Taylor-Nordin approach, like Barkatullah (2002), Billings (1982), Nieswiadomy & Molina (1989) and Terza & Welch (2001). This includes using an instrumental variable technique. The first step predicts water consumption using as explanatory variables the marginal prices for predetermined quantities – reflecting the steps of the tariff. This will give the following equation:

$$\mathbf{Con^*_{it} = f(MP_{it}, Z_{it})} \qquad \mathbf{(1)}$$

Where:

Con^*_{it} = predicted water consumption

MP_{it} = vector of prices corresponding to the predetermined quantities

Z_{it} = other exogenous variables

In our situation each household receives an implicit subsidy from the low price of the first steps. We use a variable (RSP) to measure this subsidy, setting RSP = (average price – marginal price) * quantity.

The equations relevant here are as follows:

$$\mathbf{MPIV = f(Con^*_{it})} \qquad \mathbf{(2)}$$

$$\mathbf{RSP = f(Con^*_{it})} \qquad \mathbf{(3)}$$

Using the actual tariff structure, we calculate the instrumental values for MP and RSP, using the predicted quantities from step 1. These instruments are used in the second step to estimate water consumption. A log-linear demand model is adopted, which implies that the coefficients of the explanatory variables are expressed as elasticities. However, the RSP is included in real value to avoid unstable estimators[7]. The variables used in the econometric analyses are listed in table 5 below:

Table 5: LIST OF VARIABLES

Variable Name	Description
lcon	Natural Log of Water Consumption
lrmp	Natural Log of real marginal prices
lrmpiv	Natural Log of real instrumented marginal prices
rspivp	The adjusted[8] RSP (instrumented RSP – based on predicted consumption)
realrspp	Actual RSP (based on actual consumption)
lplot	Natural Log of Plot Size
ltemp	Natural Log of Average Maximum Monthly Temperature

[7] Alternative model specifications were tested, and the findings of this process indicated that including the log of RSP will lead to significant impacts on the results. This is due to the adjustment of the RSP, first multiplying it by -1 to make it positive (see footnote 7), and then adjusting it to include observations with zero values. The latter adjustment has significant impacts on the sign of the coefficient for the instrumented real marginal price, when the log of RSP is taken (it changes from a positive to a negative sign, when adjusting RSP by 0.5 and 2 respectively). This implies that the log specification of RSP makes the estimates of the price elasticity of demand sensitive to these adjustments. Since the RSP is of no major interest in this study, we use the real instrument instead of its log value, and this produces stable results.

[8] Following Renwick & Green (1999), the RSP is linearly transformed to make it a positive value. This would provide a more intuitive explanation for RSP, which implies that we assume that we obtain a positive relationship between RSP and consumption.

lrain	Natural Log of Average Maximum Monthly Rainfall[9]
lhh	Natural Log of Household Size
y1	Dummy: income categorical variable (1001-5000)
y2	Dummy: income categorical variable (5001-10000)
y3	Dummy: income categorical variable (10001-20000)
y4	Dummy: income categorical variable (20001-)
bath	bath dummy, yes if household has a bath
garden	garden dummy, yes if household has a garden
wmachine	washing machine (automatic), yes if household has a washing machine
d2000	Dummy: Year 2000, when water restrictions were imposed
d2001	Dummy: Year 2001, when water restrictions were imposed
lage	Natural Log of average age of household
int1	y1*lrmpiv
int2	y2*lrmpiv
int3	y3*lrmpiv
int4	y4*lrmpiv

The water demand model (for the fixed effects, random effects and pooled regression) is estimated based on the following equation:[10]

lcon = f(lrmpiv, realspivp, ltemp, lhh, lplot, lrain, y1, y2, y3, y4, bath, garden, wmachine, d2000, d2001, lage) (4)

In the case of the OLS (without the instrumental variables), the equation is as follows:

lcon = f(lrmp, realrspp, ltemp, lhh, lplot, lrain, y1, y2, y3, y4, bath, garden, wmachine, d2000, d2001, lage) (5)

[9] A number of rainfall observations have been adjusted (by adding 0.1 mm) to allow the inclusion of these observations (to take the log of rainfall).

[10] The study includes only selected explanatory variables, based on the analysis of previous studies.

Analysis of Different Slopes and Intercepts of the Demand Curves (based on Income Group)

A further step in the econometric analysis was to explore the possibility of identifying a different slope for the demand curves of the different income groups. The model is thus extended to provide a model with different slopes and intercepts (Wonnacott & Wonnacott, 1979).

This method applies the following model:

$$\mathbf{lcon = \alpha + \beta\ lrmpiv + \gamma\ y1 + \delta\ y2 + \varepsilon\ y3 + \zeta\ y4 + \eta\ realrspivp + \theta\ ltemp + \iota\ lhh + \kappa\ lplot + \lambda\ lrain + \mu\ d2000 + \nu\ d2001 + \xi\ lage + \rho\ int1 + \sigma\ int2 + \tau\ int3 + \chi\ int4 + \psi\ bath + \omega\ garden + \ddot{\imath}\ wmachine} \quad \mathbf{(6)}$$

The variables int1 to int4 represent the interaction terms. This provides a slope for the demand curve for each income group (as compared to the reference income group, which is Y_0). Thus, for income group 1, the slope would be as follows:

$$\begin{aligned} \mathbf{lcon} &= \mathbf{\alpha + \beta\ lrmpiv + \gamma + \rho(y1 * lrmpiv)} \\ &= \mathbf{(\alpha + \gamma) + (\beta + \rho)\ lrmpiv} \quad \mathbf{(7)} \end{aligned}$$

For all equations we estimate the parameters based on standard assumptions on the error terms.

6 Data analysis and Results

6.1 Panel Data Analysis

The results for the random effects model are given in Tables 6 and 7. We find a price elasticity for the poorest group of -0.245, varying - but close to zero - for all low income segments. However, for the richest group of consumers the consumption of water is more elastic, with a price elasticity of -0.537. This supports the assumptions of the theoretical analysis of Moilanen and Schulz (2002), and it also supports the empirical findings of the contingent valuation study of Veck and Bill (2000). The overall goodness of fit for the random effects model, R^2, is 0.2914.

Tables 6 and 7 also report the results from using a fixed effects model. In this case we assume that $Zi'\alpha = \alpha_{i,}$ thus a household-specific *constant* term is added into the regression model. This is given by the following equation (Greene, 2003):

$$Y_{it} = X_{it}'\beta + \alpha_i + \varepsilon_{it}$$

In the fixed effects approach all the time invariant variables drop out of the regression. The price elasticity of demand is still relatively inelastic, -0.277, not very different from the random effect model, and, as we will see later, higher than in the case of the pooled regression. However, the goodness of fit for the model is extremely low, which indicates that the fixed effects model may not be appropriate to use in this case. The reason for this is obvious. In our case the price variation for each segment of consumption is low (see Table 1). This means that each household usually only faces minor price changes – only for the highest levels of consumption are price changes substantial. The other time-dependent variables (like climate) change a lot over the year. The main improvement in the analysis is really to add observations from other households to obtain price variations, while controlling for the important differences in background. Using the fixed effects model little is left to allow for studies of price shifts. The link between price and consumption of water is probably quite stable over the five years studied, while consumption trends and climate may change. There is thus good reason to use the information between households, which cannot be done using this specification. The low R^2 confirms this. We still want to include in our analysis the effect of the data selected from different households. We therefore prefer the random effects model as an alternative specification of the model.

Comparing the two panel model specifications give quite similar estimates for price elasticity. Temperature, the average age of the household, plot size and household size all have the expected positive signs and are all significant. For example, a 1% increase in household size will increase water consumption by 0.66%. The interaction dummies are included to obtain different price elasticities for the different income groups. This is shown in table 7.

All elasticities are negative, and the interaction dummies are all significant. The dummies for bath, garden and washing machine all have the correct sign. They are also statistically significant, except for garden.

Table 6: RESULTS FOR THE FIXED EFFECTS MODEL AND THE RANDOM EFFECTS MODEL

Variable	Fixed Effects Model Coefficients	Random Effects Model Coefficients
lrmpiv	-0.2779307 *-8.40****	-0.2447449 *-7.63****
realrspivp	0.0038866 *8.50****	0.0036803 *8.12****
ltemp	0.4569896 *14.76****	0.4621736 *14.94****
lrain	0.0167764 *4.49****	0.173745 *4.65****
lhh	dropped	0.6627202 *10.63****
lage	0.6501659 *7.10****	0.4105762 *5.95****
lplot	dropped	0.1870717 *2.74****
d2000	0.0538953 *5.41****	0.0419052 *4.40****
d2001	0.0459879 *5.11****	0.0389932 *4.42****
y1	dropped	-0.2429821 *-3.14****
y2	dropped	-0.1684536 *-1.60*
y3	dropped	-0.2034677 *-1.48*
y4	dropped	0.705035 *4.24****
int1	0.0952876 *3.14****	0.0956332 *3.16****
int2	0.1077015 *3.55****	0.1063796 *3.51****

int3	0.1561213 *4.11****	0.1571161 *4.14****
int4	-0.3035631 *-5.74****	-0.2924751 *-5.55****
bath	dropped	0.2102543 *2.92****
garden	dropped	0.0863694 *1.30*
wmachine	dropped	0.2024698 *3.04****
constant	-0.6704956 *-2.12***	-2.17802 *-4.90****
R^2 – within	0.0403	0.0398
R^2 – between	0.0368	0.3771
R^2 – overall	0.0159	0.2924
Number of observations	13621	13621
Number of groups	275	275

Source: Own Calculations (2005)

Note: 1) T-values in italics.

2) Level of significance: * - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level**

Table 7: PRICE ELASTICITIES FOR THE DIFFERENT INCOME GROUPS – FIXED EFFECTS MODEL AND RANDOM EFFECTS MODEL

Income Group	Fixed Effects Model Price Elasticity	Random Effects Model Price Elasticity
Group 0 (Y_0 = R0 – R1000)	-0.27793	-0.24474
Group 1 (Y_1 = R1001 – R5000)	-0.18264	-0.14911
Group 2 (Y_2 = R5001 – R10000)	-0.17023	-0.13837
Group 3 (Y_3 = R10001 – R20000)	-0.12181	-0.08763
Group 4 (Y_4 = R20001 -)	-0.58149	-0.53722

Source: Own Calculations (2005)

HAUSMAN TEST

Using panel data we have to test if the strong assumptions of the random model can be applied to our sample. The Hausman specification test allows one to test for orthogonality of the random effects and the regressors (Greene, 2003, 301).

The results for the Hausman test in our case reflect a chi2(11) = 16.54 and Prob>chi2 = 0.1221. This result implies that we cannot reject the null hypothesis that the effects are uncorrelated. Thus, based on this result and the intuitive economic reasoning discussed above, the random effects model seems to be the better choice. It seems to be better than the fixed model due to two reasons. First, the R^2 is much higher (caused by the fact that we now allow for the inclusion of inter-household variation in the estimation), and it seems that the assumptions needed, apply. It also seems better than the pooled regression, since now we take account of that all observations are linked to 275 households.

6.2 IV and OLS Regressions – using pooled data

It is good arguments for using panel analysis, since this way includes more of our information in the model. However, we have also performed the same analysis with all data pooled, and our results are presented in table 8. The table reflects both the results for the IV and the OLS techniques. With the exception of realrspp and realrspivp, all other variables' coefficients reflect elasticities. The total number of observations is the same for both techniques.

We see that the OLS gives a positive sign of the estimate for the price elasticity, lrmp = 0.202, as expected (see also Nieswiadomy & Molina (1989)). We know that in our study a high consumption of water goes together with a high marginal price due to the IBT. This means that the error term will be correlated to the price, because sometimes the error makes us cross from one step to another. The IV technique is introduced to adjust the estimates accordingly. Barkatullah (2002) also finds a positive coefficient for the price variable. As expected, the sign of the rate structure premium variable, realrspp, is positive and significant.

With the IV technique, the marginal price coefficient, lrmpiv, is -0.101. It is negative and quite inelastic. Both the price elasticity and the RSP coefficients are highly significant. The difference in the estimation results from the OLS to the IV estimation strongly supports the hypothesis that for such models the OLS is an inconsistent estimator.

The income dummy variables are analyzed against the reference Y_0, which is the income category of R0 – R1 000, the lowest income bracket on the survey questionnaire. Generally it is difficult to obtain income data that are reliable. Respondents tend to be wary of providing information on their incomes, especially in this case, where they first had to sign a permission slip, giving the municipality permission to release the water consumption data. However, the use of categorical variables would have assisted in a more realistic response. The results for each of the income dummy variables give conflicting results. It indicates that water consumption for households in categories 1, 2 and 3 would decline as compared to the reference category, whereas households in category 4 will consume more water as compared with the reference category. The coefficients are significant only for categories 1 and 4.

The dummies for years with water restrictions (2000 and 2001) vary in their sign over the techniques. For the OLS, the dummies show that water consumption is negatively related to the implementation of water restrictions during these years. However, for the IV technique, the coefficients switch sign and are also not significantly different from zero. The average age of the household members also influences the water use, and it is statistically significant. Three dummies on household characteristics are added: bath, garden and washing machine. All three dummies have positive signs, which are intuitively correct, and they are all statistically significant. For example, water demand will increase if there are more baths in the household. Also, more washing machines imply a higher water usage. More gardens also imply higher water usage.

Table 8: RESULTS FOR THE IV AND OLS REGRESSIONS (POOLED DATA)

	IV Technique		**OLS Technique**	
Variable	**Coefficient**	**t-value**	**Coefficient**	**t-value**
lrmp	---	---	0.2020199	*65.15****
realrspp	---	---	0.009009	*93.80****
lrmpiv	-0.1005371	*-3.47****	---	---

realrspivp	0.0041739	*6.74****	---	---
ltemp	0.4267427	*9.10****	0.1489331	*5.14****
lhh	0.509092	*38.42****	0.233881	*28.65****
lplot	0.2227348	*17.92****	0.1075951	*14.33****
lrain	0.0157308	*2.77**	-0.0069177	*-1.96***
y1	-0.0854707	*-6.62****	-0.0175389	*-2.17***
y2	-0.0287127	*-1.67**	0.0116096	*1.07*
y3	-0.0281703	*-1.27*	0.0024696	*0.18*
y4	0.210413	*7.77****	0.1267694	*8.08****
d2000	0.0055805	*0.42*	-0.110031	*-13.40****
d2001	0.0163388	*1.26*	-0.0936172	*-12.29****
bath	0.2168231	*15.47****	0.1448449	*16.43****
garden	0.0876506	*7.35****	0.0643016	*8.56****
wmachine	0.1894872	*16.51****	0.1033315	*14.24****
lage	0.127163	*7.01****	0.0545631	*4.80****
constant	-1.240678	*-6.67****	0.6747479	*5.97****
Number of observations	13621		13621	
Adjusted R^2	0.3018		0.7231	

Source: Own calculations (2005)

Note: 1) T-values in italics.

2) Level of significance: * - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level**

3) Robust regressions did not produce any significantly different results.

6.3 Analysis of Different Slopes of the Demand Curves (based on Income Group)

For the pooled data we find that the introduction of possible different slopes adds to the results from the data. Tables 9 and 10 demonstrate that the elasticity of demand differs between the groups, specifically between the high income segment and the rest of the sample. The results show that almost all the elasticities are negative. The first three groups (group y0 to group y2) have price elasticities ranging from -0.11836 to -0.1406304. A strange result is that of income group y3 – here the price elasticity is positive, but very close to zero. Income group 4 has a price elasticity of -0.64061, which is significantly different from the other groups. It is relatively more elastic than the other groups, probably reflecting that higher income groups are more responsive to tariff changes, given that they consume water for purposes other than basic needs. Two of the dummies of the low income groups are, however, not significant (int1 and int2).

Table 9: DIFFERENT SLOPE AND INTERCEPT REGRESSION BY INCOME GROUP (IV), COMPARED TO POOLED DATA REGRESSION WITH SAME SLOPE (IV)

	IV, different slope		IV, same slope	
Variable	**Coefficient**	**t-value**	**Coefficient**	**t-value**
lrmpiv	-0.1406304	*-3.45****	-0.1005371	*-3.47****
realrspivp	0.0049569	*7.89****	0.0041739	*6.74****
ltemp	0.4245069	*9.09****	0.4267427	*9.10****
lhh	0.5061529	*37.78****	0.509092	*38.42****
lplot	0.2162305	*17.37****	0.2227348	*17.92****
lrain	0.0163624	*2.89****	0.0157308	*2.77**
y1	-0.1092477	*-2.48***	-0.0854707	*-6.62****
y2	-0.0429002	*-0.87*	-0.0287127	*-1.67**
y3	-0.1909581	*-3.10****	-0.0281703	*-1.27*
y4	0.9404351	*8.62****	0.210413	*7.77****
d2000	0.013538	*1.01*	0.0055805	*0.42*
d2001	0.023995	*1.95**	0.0163388	*1.26*
bath	0.219566	*15.59****	0.2168231	*15.47****
garden	0.0866121	*7.26****	0.0876506	*7.35****
wmachine	0.1909744	*16.67****	0.1894872	*16.51****
lage	0.1278777	*7.05****	0.127163	*7.01****
int1	0.0222696	*0.59*	---	---
int2	0.0124622	*0.31*	---	---
int3	0.1478955	*2.88****	---	---
int4	-0.4999777	*-6.65****	---	---
constant	-1.181493	*-6.32****	-1.240678	*-6.67****
Number of observations	13621		13621	
Adjusted R^2	0.3050		0.3018	

Source: Own Calculations (2005)

Note:

1) **T-values in italics.**
2) **Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level**
3) **Robust regressions did not produce any significantly different results.**

Table 10: PRICE ELASTICITIES FOR THE DIFFERENT INCOME GROUPS

Income Group	Price Elasticity
Group 0 (Y_0 = R0 – R1000)	-0.1406304
Group 1 (Y_1 = R1001 – R5000)	-0.11836
Group 2 (Y_2 = R5001 – R10000)	-0.12817
Group 3 (Y_3 = R10001 – R20000)	0.007265
Group 4 (Y_4 = R20001 -)	-0.64061

Source: Own Calculations (2005)

We see that the adjusted R^2 is slightly better in the case of different slopes and different intercepts (by income group) specification. We also find that the estimates are different for this model. We conclude that this model specification for the pooled data is better than the model with only one slope and intercept.

6.4 Some more comments on the model specification

So far we have model specifications that yield interesting results and that can be explained with consumer theory. We can justify the use of a 2SLS approach. However, we also want to investigate other model specifications. We use the pooled data to demonstrate this.

First, we must check the changes in the weighted sum of squared residuals when using the IV technique, but they change only slightly. We have no information on the shape of the demand curve, and it is reasonable to check at least some alternatives to our log-log model. We do so with a linear demand curve and a semi-log demand curve. None of these alternative model specifications fit better to the data than the one used in the text. The adjusted R^2 for the different model specifications are reflected in the table 11. The table also distinguishes between slope coefficients for the different income groups. It indicates that the log-log model provides the best fit. Also, allowing for different slopes by income group does not affect the R^2 much.

Table 11: COMPARISONS OF THE GOODNESS OF FIT FOR DIFFERENT MODEL SPECIFICATIONS – ADJUSTED R^2

	LOG-LOG	SEMI-LOG	LINEAR
Full Sample (No interaction dummies)	0.3018	0.2809	0.2121
5 Income Groups (4 interaction dummies	0.3050	0.2844	0.2189
3 Income Groups (2 interaction dummies)	0.3029	0.2828	0.2167
2 Income Groups (1 interaction dummy)	0.3026	0.2825	0.2160

Source: Own Calculations (2005)

We find that all model specifications have relatively small values for adjusted R^2. This seems to be a common problem for studies utilizing the instrumental variable technique, see for example Strand & Walker (2003). It looks like many factors outside our modeling influence the registered water consumption. This can be due to consumption behaviour not incorporated in the model, problems of registration of consumption (like estimations instead of actual readings for many months), or problems in the data collection.

Using the log-log model, we can compare results for different specifications of the income groups. Table 12 reflects these results. For all specifications we still see a big difference for the high income group as compared to the lower income groups, and income group Y_3 is still a problematic one. We conclude that our study supports the existence of different slopes between high and low income groups, and the slope coefficient is significantly higher for the highest income group (i.e. the rich consumers). This is in line with the idea that households in this group are more sensitive to a price change than others consumers.

Table 12: COMPARISON OF PRICE ELASTICITIES FOR DIFFERENT INCOME GROUPS (LOG-LOG MODEL)

	Adjusted R^2	Y_0 (Base Group)	Y_1	Y_2	Y_3	Y_4
Full Sample (No interaction dummies)	0.3018	-0.1005371	---	---	---	---
5 Income Groups (4 interaction dummies	0.3050	-0.1406304	-0.11836	-0.12817	0.007265	-0.64061
3 Income Groups (2 interaction dummies)	0.3029	-0.1171518			0.001217	-0.64852
2 Income Groups (1 interaction dummy)	0.3026	-0.1046109				-0.64958

Source: Own Calculations (2005)

We can easily compare the slopes of the three model specifications, see Table 13. Observe that only the log-log model provides a price elasticity estimate. We see that the t-values do not change substantially, but the semi-log coefficient is not significantly different from zero. However, allowing for different slopes of the demand curve for each income group shows that the semi-log model has a counter-intuitive positive slope for the demand curve, and the linear model specification is a bit less significant. Since we have earlier concluded that there is no gain in the fit of the model by using a different specification other than log-log, this analysis supports our conclusion.

Table 13: COMPARISON OF MODEL SPECIFICATION: FULL SAMPLE (no interaction dummies)

	Full Sample (No interaction dummies)			Full Sample -Five Income Groups (4 interaction dummies		
	Log-Log	Semi-Log	Linear	Log-Log	Semi-Log	Linear
Instrumented real marginal price	-0.105371 *-3.47****	-0.0138053 *-1.05*	-1.288234 *-3.95****	-0.1406304 *-3.45****	0.0200449 *1.21*	-0.9953838 *-2.44***
Instrumented rate structure premium	0.0041739 *6.74****	0.0035084 *4.48****	0.1494923 *7.73****	0.0049569 *7.89****	0.0035656 *4.56****	0.1544673 *8.01****

Source: Own Calculations (2005)
Level of significance: * - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level**

7 Conclusions and some policy implications

Given the recurring droughts experienced in almost all provinces of South Africa, there should be an emphasis on utilizing all possible policies to change the consumption patterns of consumers, given the presumption that they consume too much. To do so, water managers must know the shape of their demand curves. With this knowledge, they will better be able to design policies that take into account the multiple objectives of different policies.

In the case of pricing policy, it is evident from most studies that demand is price inelastic, at least in the short run. However, our study also concludes that while low income groups hardly change their consumption due to price shifts, the higher income groups are relatively more price sensitive. We find that the price elasticity differs significantly between the high income segment (-0.53722) and the rest of the households (low income -0.244744). A 10% price increase facing the marginal consumption of this group will trigger a 5.4% reduction in their water consumption.

This has policy implications. First, an overall policy to manage water and restrict consumption can build on the price mechanism only for the upper segment of the market. Since the high income consumers also have the largest consumption of water, an adjustment of the higher steps of an IBT may work very well. For the low income groups other measures must be used, pricing cannot be used as an efficient management tool for their consumption of water. These can include quantitative restrictions, other physical restrictions, campaigns etc. Price increases may have implications for equity, especially in circumstances where many people cannot afford to even pay for the basic consumption of water.

Second, our estimates can be useful to streamline the IBT structure. Moilanen & Schulz (2002) show how an IBT will vary according to the welfare goals of the municipality, and also according to the demand structure for the rich and the poor. A more elastic demand for the rich group is a crucial factor to understand how to use an IBT for equity purposes. Our study may add to this side.

The research supports a model specification using constant price elasticity for all levels of consumption, while it differs according to the income level of the household. It seems that the main split in the consumption patterns come in between the high income groups and the rest of the population. This is so even if we control for the differences in the water demanding appliances and household characteristics. The model results are also sensitive to the model specification, which implies that this needs careful attention. As with many other studies, most of the variation in water consumption seems to be explained by factors outside the model.

Our results seem to compare well with other studies. However, the consumption patterns in Cape Town may not reflect the overall patterns in the developing world. Our study does not include the very poor and destitute groups, who only have unmetered water. We also focus on urban, residential consumption and rural areas probably face different management problems. This opens for other, interesting and relevant water demand research. However, for all consumers without metered water demand, management by use of pricing is irrelevant. A proper and fair management of a scarce resource needs other measures in these cases.

Our main conclusion is anyway that a social manager of water must have a lot of knowledge of the water demand structure to impose a socially efficient pricing structure of water. Financial reasoning alone cannot care for this, and it may lead to pricing policies that are bad for water distribution.

8 Reference List

Barkatullah, N. 2002. OLS and Instrumental Variable Price Elasticity Estimates for Water in Mixed-Effect Models under a Mutlipart Tariff Structure. London Economics.

Billings. R.B. 1982. Specification of Block Rate Price Variables in Demand Models. Land Economics. Vol. 58, No. 3.

City of Cape Town. 2004. Current Water Resource situation and the implementation of water restrictions (23/09/2004). http://www.capetown.gov.za/water/restrictions/Restrictionsoverview.pdf.

Chicoine , D. L, & Ramamurthy, G. 1986. Evidence on the Specification of Price in the Study of Domestic Water Demand. Land Economics. Vol. 62. No. 1.

Dalhuisen, J., Florax, J., de Groot, H. & Nijkamp, P. 2003. Price and Income Elasticities of Residential Water Demand: A Meta-Analysis. Land Economics. Vol. 72. No.2.

Gracia, F, Valinas, A. & Martínez-Espiñeira, R. 2001. The Literature on the Estimation of Residential Water Demand. Elsevier Science.

Green, W. 2003. Econometrics Analysis. 5th edition. Prentice Hall. Upper Saddle River. NJ. USA.

Gunatilake, H., Gopalakrishnan, C. & Chandrasena, I. 2001. The Economics of Household Demand for Water: The Case of Kandy Municipality, Sri Lanka. Water Resources Development. Vol. 17. No. 3.

Gujarati, D. 1988. Basic Econometrics. 2nd edition. McGraw-Hill International Editions. Singapore.

Höglund, L. 1999. Household demand for water in Sweden with implications of a potential tax on water use. Water Resources Research. Vol. 35. No. 12.

Howe, C. & Linaweaver, F. 1967. The impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure. Water Resources Research. Vol. 3. No.1.

Jones, C. & Morris, J. 1984. Instrumental Price Estimates and Residential Water Demand. Water Resources Research. Vol. 20. No. 2.

Moilanen, M. & Schulz, C-E. 2002. Water Pricing Reform, Economic Welfare and Inequality. South African Journal of Economic and Management Sciences. NS. Vol. 5.

Nieswiadomy, M. L. & Molina, D. J. 1989. Comparing Residential Water Demand Estimates under Decreasing and Increasing Block Rates Using Household Data. Land Economics. Vol. 65. No. 3.

Palmer Development Group. 2001. Free Basic Water. Implementation Strategy Document. Prepared for Director: Interventions and Operations Support.
http://www.dwaf.gov.za/FreeBasicWater/docs/Implementation%20Strategy%20version%208.3.pdf.

Renwick, M. & Green, D. 1999. Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight Water Agencies. Journal of Economics and Management. Vol. 40. 37-55.

Renzetti, S. 2002. The Economics of Water Demands. KluwerAcademic Publishers. USA.

Rietveld, P., J. Rouwendal and B. Zwart. 1997. Estimating water demand in urban Indonesia: A maximum likelihood approach to block rate pricing data. Working Paper, Tinbergen Institute, Amsterdam

Stephenson, D. 1999. Demand Management Theory. Water SA. Vol. 25. No. 2.

Strand, J. and I. Walker. 2003. Water markets and demand in Central American Cities. Working paper, Inter-American Development Bank.

Terza, J. V. & Welch, W. P. 2001. Estimating Demand under Block Rates: Electricity and Water. Land Economics. Vol. 58. No. 2.

Vuuren, D.S., Van Zyl, H. J. D., Veck, G. A. and Bill, M. R. 2004. Payment strategies and price elasticity of demand for water for different income groups in three selected urban areas. WRC Report No. 1296/1/04. Water Research Commission.

Wooldrigde, J. M. 2002. Econometric Analysis of Cross Section and Panel Data. The MIT Press. Cambridge, Massachusetts.

Wonnacott, R.J.& Wonnacott, T. H. 1979. Econometrics. 2nd edition. John Wiley & Sons. New York.