Study on Water Tariff Reform and Income Impacts in China’s Metropolitan Areas: The Case of Beijing

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By

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Chapter 1  Beijing’s water resources status and management

1.1 Overview of water resources status

As a capital in the world, Beijing has been suffering from a water shortage. The total amount of water resources is 3.629 billion m$^3$. The per-capita water resource is only 300 m$^3$, which is 1/8 of China’s average level and 1/32 of the world’s, which is far below the average 3000m$^3$/person, and even lower than the severe water shortage standards of 1000 m$^3$/person.

Precipitation: Beijing is one of the areas in Northern China that has a large amount of rainfall. The average annual rainfall is about 585mm and the extreme values are 1406mm and 272mm respectively. From June to September about 85% of the total rain falls, and sometimes 70% of the annual total falls during the last ten days of July and the first ten days of August. This combination of uneven distribution over time and space makes the water situation in Beijing even worse; sometimes it results in extreme water shortage.

Surface water: About 90% of Beijing’s surface water is rooted in outer areas. The total average amount of surface water resources is 2.178 m$^3$. Eighty-five reservoirs and other irrigation works have been built since the 1950s-1960s, of which, Guanting reservoir and Miyun reservoir are the most important resources of surface water for Beijing.

Ground water: Beijing is one of the cities which mostly depends on a ground water supply; about 60% of the total water supply is from ground water. The total amount of ground water resources is 2.521 m$^3$. There are seven major large water plants exploiting the ground water in Beijing.

1.1.1 The precipitation is 585mm annually and is uneven in distribution

The average annual precipitation is 585mm. The precipitation in Beijing distributes unevenly across space and time. First, about 85% of the annual precipitation is highly centralized from June to September. Second, as shown in Fig1, there are great varieties from year to year. The minimal precipitation per year is 370.4mm and the maximal is 724mm from the year 1988 to 2003. Third, the abundant and low water periods are interlaced across time.
1.1.2 With 300m³ water resources per capita, Beijing is a severe water shortage city

From Fig 2, the per capita water amount is about 300 m³ which is 1/8 of China’s and 1/32 of the world’s, which is far below the average 3000m³/person, and even lower than the severe water shortage standards of 1000 m³/person.

1.1.3 Serious water resources situation in Beijing

1.1.3.1 Water supply and utilization

Beijing’s water is mainly supplied for agriculture, industry, and domestic uses. Table 1 shows the uses of each category of users. Agriculture is the largest user, which accounts
for 44.6% in 2002, while it was 50.6% in 1993. In the summer of 1997, Beijing banned the use of water from reservoirs for irrigation.

Industry uses about 21.8% of water. Amongst industrial users, the chemical industry accounts for 25%, the steel and iron industry accounts for 18.8%, the building materials and mining industry accounts for 6.7%, the textile industry accounts for 6.5%, and the food processing industry is 6.1%.

Municipal water users include organizations, businesses, and residents. Residential water is mainly supplied by tap water from 11 tap water plants in Beijing with a capacity of three million m$^3$.

Agricultural water usage is declining, while industry usage is almost unchanged; and, there is slow growth for both domestic and municipal use.

### Table 1  Water usage by sector in Beijing, 2002

<table>
<thead>
<tr>
<th>Sector</th>
<th>Usage (millions m$^3$)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1545</td>
<td>44.6%</td>
</tr>
<tr>
<td>Industry</td>
<td>754</td>
<td>21.8%</td>
</tr>
<tr>
<td>Municipal and residents</td>
<td>1083</td>
<td>31.3%</td>
</tr>
<tr>
<td>Environment water</td>
<td>80</td>
<td>2.3%</td>
</tr>
<tr>
<td><strong>Total supply</strong></td>
<td><strong>3,462</strong></td>
<td><strong>44.6%</strong></td>
</tr>
</tbody>
</table>

Data sources: <Beijing water resource report> 2002

### Table 2  Water usage by sector in Beijing, 2005

<table>
<thead>
<tr>
<th>Sector</th>
<th>Usage (millions m$^3$)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1322</td>
<td>38%</td>
</tr>
<tr>
<td>Industry</td>
<td>680</td>
<td>20%</td>
</tr>
<tr>
<td>Municipal and residents</td>
<td>1338</td>
<td>39%</td>
</tr>
<tr>
<td>Environment water</td>
<td>80</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total supply</strong></td>
<td><strong>3,450</strong></td>
<td><strong>38%</strong></td>
</tr>
</tbody>
</table>

Data sources: <Beijing water resource report> 2005

1.1.3.2  **Total water usage has been decreasing in recent 10 years**

Fig. 3 shows the trend of water usage in recent years. Total water usage increased from 41.12 billion m$^3$ in 1990 to 46.43 billion m$^3$ in 1992 and then declined after 1992. It has declined fast since 1999.
1.1.3.3 Domestic and municipal water use has been increasing in the most recent 10 years

Domestic and municipal water usage has been consistently increasing. As shown in Fig. 4, it increased from 704 million m$^3$ in 1990 to 13.39 hundred million m$^3$ in 2000. We can conclude from Fig. 3 and 4, that the proportion of municipal and domestic usage increased from 17.12% in 1990 to 39.00% in 2005.

1.1.3.4 The serious water resources situation faced by Beijing in the future

With social and economic development, the conflict between the supply and demand of water has become appreciatingly more serious and the availability of water is becoming a
bottleneck in the development in Beijing.

It was projected that by 2010, the water demand in Beijing will be between 5.698 billions m$^3$ and 5.703 billions m$^3$, while the surface and underground water can only supply 4.088 billions m$^3$ per year as an average, and the lowest and lower water available a year will be around 3.754 billions m$^3$ and 3.399 millions m$^3$. So the deficit will be between 1.615 billions m$^3$ and 2.299 billions m$^3$.

Table 3  Primary water resource supply, demand and balance table for Beijing

<table>
<thead>
<tr>
<th>Area</th>
<th>Item</th>
<th>Year 2005</th>
<th>Year 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50% 75% 95%</td>
<td>50% 75% 95%</td>
</tr>
<tr>
<td>Whole city</td>
<td>Supply</td>
<td>41.33</td>
<td>37.79</td>
</tr>
<tr>
<td></td>
<td>Demand</td>
<td>49.27</td>
<td>50.59</td>
</tr>
<tr>
<td>Urban area</td>
<td>Supply</td>
<td>18.45</td>
<td>15.95</td>
</tr>
<tr>
<td></td>
<td>Demand</td>
<td>20.52</td>
<td>20.65</td>
</tr>
<tr>
<td></td>
<td>Balance</td>
<td>-2.07</td>
<td>-4.70</td>
</tr>
</tbody>
</table>

1.2 Problems identified regarding the water supply and it’s utilization in Beijing

1.2.1 Problems

(1) Water availability is low:

There is no large river across Beijing and the water supply mainly depends on underground water and natural precipitation. The underground water greatly decreases and the water table declines too, due to over-exploring. There were five drought years since 1999 in Beijing, and the average annual precipitation from 1999 to 2003 was only 425mm.

(2) Over exploration of underground water

The over-exploration of underground water caused serious ecological and environmental problems, of which the declining of water table is the most serious. Comparing 1960, the underground water table decreases 12.17m in 2000, and decreased 8.12m comparing with

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late 1980s.

(3) **Serious pollution of surface water**

Fig. 5 shows that about 2.4 million m$^3$ of wastewater is being discharged daily, while the treatment rate is quite low. According to the “2005 Environmental Quality Report in Beijing,” only 19 sections of 71 sections of rivers being monitored can reach the water quality requirement. The water quality in 588.27 km of 1464.64 km of rivers being monitored were in the fourth and fifth grade or worse than fifth, which accounts for 39.8% of the total length of the rivers being monitored.

![Graph showing daily discharge of domestic sewage, daily treatment of municipal wastewater, and treatment rate of urban sewage from 1990 to 2004.](image)

**Data sources:** Yearly Beijing water resource report

**Fig 5. Sewage drainage and treatment in Beijing**

### 1.2.2 Main reasons

The problems identified above are mainly caused by the growth of population and by agriculture and industrial activities. In addition, more regulatory problems can be summarized:

(1) **Low rate of water charges and low price of water**

The price of water in Beijing was only 0.12 RMB from 1981–1991, while it increased 0.30 RMB in 1996 and 1.6 RMB in 1999. The price of water has increased largely since 2000 and it has reached 3.7 RMB since 2004. This low price of water resulted in waste.

(2) **Awareness about water**

For a long time, the public and government did not fully realize the shortage of water, and did not have the concept of full cost pricing. Beijing introduced the sewage treatment charge in 1997 and the water resources fee in 2002.
（3）**Inefficient use of water behaviors and lower treatment**

About 22% of municipal water was being treated in 2004, and about 0.2 billion tons of sewage was being directly discharged into rivers.

（4）**Lower recycling rate**

By the year of 2008, water recycling would reach 50%, but that is still much lower than the 80% of the industrialized countries.
2.1 General situation and trend of residential water use in Beijing

2.1.1 General situation of residential water use

Domestic residential water use is a major part of municipal water utilization. According to the research of industrial countries (Howe and Linaweaver’s research in U.S., 1976; Grima’s research in Canada, 1971; Hanker and Smart’s research in Australia, 1979), residential water use can exceed more than half of the total of municipal water uses. Since the 1980’s, residential water use increased. In 2003, 552.01 millions m³ of tap water was sold in which 245.91 million m³ was for residential use and accounted for 44.55%, according to the Beijing Waterworks Group’s news

Based on the investigation by the Beijing Water Saving Office and Beijing Economic Information Center in 2003, the residential water use in Beijing is about 104.14 L/person day; but it is still lower than that in developed countries.

Table 4 Residential household water use in some EU countries (2001a.)

<table>
<thead>
<tr>
<th>Country</th>
<th>Household water use per person per day</th>
<th>Country</th>
<th>Household water use per person per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>260</td>
<td>Holland</td>
<td>173</td>
</tr>
<tr>
<td>Austria</td>
<td>215</td>
<td>Norway</td>
<td>167</td>
</tr>
<tr>
<td>Italy</td>
<td>214</td>
<td>French</td>
<td>161</td>
</tr>
<tr>
<td>Sweden</td>
<td>195</td>
<td>Britain</td>
<td>161</td>
</tr>
<tr>
<td>Norway</td>
<td>183</td>
<td>Finland</td>
<td>150</td>
</tr>
<tr>
<td>Spain</td>
<td>181</td>
<td>Germany</td>
<td>135</td>
</tr>
<tr>
<td>Denmark</td>
<td>176</td>
<td>Belgium</td>
<td>116</td>
</tr>
</tbody>
</table>


From the date revealed during the investigation of Beijing’s household water use we find how it is specifically used (see Table 5). It is seen that it is mainly used for meeting the basic needs of the residents, e.g., drinking water, cleaning, bathing, washing, and toilets. The result is similar to the investigation data of Hebei’s 12 cities. However, the residential

2 http://www.bjwatergroup.com/htm/supportwater/cost.htm
household water use proportion is lower than the 12 cities in the Hebei Provinces, which may reflect the fact that the social services conditions in Beijing are better than those cities, maybe because they have less time to cook and eat at home.

Table 5 Beijing’s resident water use structure

<table>
<thead>
<tr>
<th>Use types</th>
<th>Current volume (L/Person·dDay)</th>
<th>Current proportion</th>
<th>Past volume (L/Person·dDay)</th>
<th>Past proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking water</td>
<td>2.25</td>
<td>2.16</td>
<td>48</td>
<td>32</td>
</tr>
<tr>
<td>Cooking and cleaning dishes</td>
<td>5.43</td>
<td>5.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning bathroom</td>
<td>27.00</td>
<td>25.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>House cleaning （floor, furniture, yard, etc.）</td>
<td>4.25</td>
<td>4.08</td>
<td>43.95</td>
<td>29.3</td>
</tr>
<tr>
<td>Self cleaning （washing face, brushing tooth, bathing etc.）</td>
<td>42.51</td>
<td>40.82</td>
<td>40.05</td>
<td>26.7</td>
</tr>
<tr>
<td>Washing clothes</td>
<td>22.53</td>
<td>21.63</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Watering flowers and growing fishes</td>
<td>0.17</td>
<td>0.16</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>104.14</td>
<td>100.00</td>
<td>150.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Data sources: The investigation report of Beijing’s resident water uses condition
Notes: * The past proportion of the total volume comes from Herry Zhang’s research, 2003.

2.1.2 Future trend of residential water use

As Beijing builds more, the coverage of tap water increases, so the use of residential water increases also. According to the projections of the water supply plan of Beijing, water use will increase by 3.42% while the population increases by only 1%. In addition, the immigrant population will also increase the demand for water in Beijing.

According to the “General situation and trend of resident water uses research,” the residential water use will increase at an annual rate of 2.7% by 2010. According to the Beijing Waterworks Group’s data, although the total amount of water sold decreased by 5% annually, the residential water use increased by 3% annually. The major contribution to this trend is the increased use of water for bathing, washing, and toilet, which closely relates to the changes in living conditions.

2.2 Beijing’s residential water pricing policy

2.2.1 Historical changes of residential water pricing policy

By introducing demand side management, pricing policy has been reformed to regulate
water resources use in Beijing since the 1990s.

Beijing started to charge the water for residential uses since 1952, and since then, the price of water has been adjusted 12 times. The historical changes of the water price can be summarized as following.

(1) **Low and steady price (1952～1991)**

The water has priced since 1952, and there was not any adjustment during 1952～1966. During the “cultural revolution,” water price was fixed at 0.12 RMB/m$^3$ in 1967, and that continued to the early 1990s. (The State Council development research center, 1990$^3$).

(2) **Water price being frequently adjusted (1991～ )**

Since 1990s, the water price in Beijing has been adjusted frequently. The current water price for domestic uses is based on the volume consumed by households, by a uniform price for each unit consumed. During the years 1991 to 2004, the government had adjusted the water price 9 times in 14 years and the price in normative term had increased for 22.33 times. After 1997, the price of water had been adjusted almost every year, and the major changes were that in 1997 and 2002, sewage charges and water resources fee were being charged as a component of the water price respectively. In 2006, Beijing’s residential water price$^4$ reached the level of 3.7 RMB/ m$^3$, the highest level in China. A “three-tier water price structure” was therefore formed, including pricing related to the tap water supply, water resource, and sewage treatment cost.

In the view of the residential water price and its components, the future pricing system will tend to recover the supply cost, including the water resources exploration and production, as well as the environmental cost, which is reflected in the sewage treatment cost. In order to more fully reflect the cost of water, the government began levying and increasing the the price on water resources and sewage treatment.

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$^4$ Beijing Development and Reform Commission. Information about water price adjusting（NO. BDRC [2004]1517）
Table 6 Residential water price in Beijing (unit: RMB/ m³)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap water supply</td>
<td>0.12</td>
<td>0.30</td>
<td>0.50</td>
<td>0.70</td>
<td>1.00</td>
<td>1.30</td>
<td>1.60</td>
<td>1.70</td>
<td>1.70</td>
<td>1.70</td>
<td>1.70</td>
</tr>
<tr>
<td>sewage treatment</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.10</td>
<td>0.10</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>cost</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.30</td>
<td>0.60</td>
<td>1.10</td>
<td>1.10</td>
</tr>
<tr>
<td>water resource</td>
<td>---</td>
<td>---</td>
<td>---</td>
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<td>---</td>
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</tr>
<tr>
<td>fee</td>
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<td>---</td>
<td>---</td>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Residential use</td>
<td>0.12</td>
<td>0.30</td>
<td>0.50</td>
<td>0.80</td>
<td>1.10</td>
<td>1.60</td>
<td>2.00</td>
<td>2.50</td>
<td>2.90</td>
<td>3.70</td>
<td>4.50</td>
</tr>
<tr>
<td>water price</td>
<td></td>
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</tr>
</tbody>
</table>

Data sources: Beijing Waterworks Group's information⁵ and yearly information about water price adjusting⁶

According to the “Capital’s water resource sustainable development and utilization plan in early 21st Century” approved by State Council⁷ and the information about water price adjustments from the Beijing Development and Reform Commission (in 2005), it was expected that the integrated water price would reach 6 RMB/m³ and residential water price would be 4.5 RMB/m³. That would be mainly due to the increase of the water resources fee and sewage treatment cost (however, this proposal was not approved).

In addition to the pricing policy adjustment and reform, the Beijing government has been seeking other policies to improve the conservation of water, for example, water supply planning and utilization quota management, etc. There was a proposal in 2004 regarding implementing the Increasing Block Tariff (IBT) pricing policy in Beijing, in addition to the requirements of the water quota on major sectors in Beijing.

According to the primary policy proposal, the proposed IBT system will have 3 blocks, with the ratio of the price level at 1:3:5. The first block was set up for 12t/month per household to meet the basic need, the second block was set up as 12–16t/month per household for improving the quality of life, and over 16t/month as the third block to satisfy special consuming demand. The proposed IBT water pricing system for residential water can be summarized as the following figure:

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⁵ [http://www.bjwatergroup.com/htm/law/18_2.htm](http://www.bjwatergroup.com/htm/law/18_2.htm)
⁶ Beijing Development and Reform Commission. Information about water price adjusting (NO. BDRC [2004]1517)
2.2.2 Other demand side management

In addition to the efforts to use pricing policy, demand side management has been widely employed by the Beijing government.

In 1981, the Beijing Municipal Government Water Saving Office had been established (which restructured as the Beijing Water Saving Management Center in 2004), the focus of urban water savings was focused on the water plan and quota management for the big users in Beijing, and to promote the awareness amongst the residents.

In 1999, Beijing published 26 policy items regarding water savings, which covered water resources exploration, utilization, savings, protection and management. This policy package can be treated as a comprehensive measure to meet the demands of the water shortage problems facing by Beijing.

On 1st Dec. 2000, “Beijing water saving regulations” were published and implemented. It clearly stated that Beijing was going to implement water use by plan, and establish water use allowances (a quota) that would be decided by water saving offices at various levels, and an increased price would be charged for those exceeding the quota issued.

In 2002, the State Council officially approved the “Capital water sustainable utilization plan in early 21st Century”, which proposed that the principles for water use in Beijing should be focused on both development and conservation, and where
possible, conservation should be the first priority.

In order to improve water savings at the household level, Beijing twice published named lists of water saving products and instruments in 1999. It required the phase out of products and instruments which could not meet the requirements for “household domestic water saving products and instruments” (CJ164 2002), including tap, toilet, and showering, etc.

Since the 1990s, the government also launched many campaigns promoting water saving facilities. In 2005, the urban areas started to implement the “one meter for one household” innovation, and to expand the coverage of the tap water meters, and to promote the volume based water use.

2.2.3 Institutional arrangement for residential water charges

Currently, the charge for water divides into 2 parts, one is called the engineering water charges, or the water supply cost, which also includes the resource water fee, and the other part is the sewage treatment fee.

2.2.3.1 The management of engineering water charges (water supply cost) and its institution

The “Urban water supply price management” issued by State Planning Commission and Ministry of Construction regulates the collection of the engineering water costs, and they are collected by the water company.

Beijing residents can pay the charges to banks or to a real estate company assigned by Beijing Waterworks Group’s (BWG) or they can be paid directly to the branches of the group.
2.2.3.2 Charge of sewage treatment fee and its institution

Currently, are collected by BWG, and BWG will deliver those charges to sewage treatment company or other treatment plants, through certain financial arrangements or through the financing sector of the government.
Chapter 3  The analysis of behavior reaction to price policy of Beijing residents

3.1 Review of the reactions of the residents to the water pricing policy reform

The impact on behavior changes of residents by water pricing policy would mainly be through the level of price and the increase of the expenditures. The impacts on the behavior and preference of the residents will be different according to the share of water expenditure in total expenditure. According to a research conducted by Ministry of Construction, “the study on urban and rural water shortage problems”, and Shi Xican (2002), if water expenditure accounts for less than 1%, there would not be an impact, if it accounts for 2%, residents started to be concerned about the water consumed, while behaviors would be changed if it reached to 5%. Yu Fan (2006) also stated that once it reached to 3%, it would imply that the water expenditure is too large to exceed the affordability of household.

The following figure shows the proportion of changes of water expenditure in total expenditure in Beijing, and it shows that currently the water expenditure is still low; for most of the income groups, it is lower than 1% (the overall proportion for all residents is 0.7%).

In Beijing there was a continuing upward adjustment of water pricing, and water prices increased faster than income, there was a slow upward trend in the proportion of expenditure. Although for most income groups, the proportion is lower than 1%, it can be projected that certain impacts on behavior changes would happen due to the frequent adjustments.

The budget ratios of water payout all increase slowly in different income-level-groups. Although they have not yet affected the water use mentality level, which is 1%, the
result shows water payout gradually takes up a more important place than before. A public opinion investigation of Beijing residents showed that the price adjusted too frequently in these years and had an indirectly had an affect on the morale endurance to change water behavior.

Fig 8. The water payout ratio of each income-level-group in recent years

3.1.1 Short-run reaction to water price increase

In short term, the residents’ behavior changes mainly referred saving water under the existing situation with no consideration to buy or install water saving facilities or instruments. The following table summary is based on the survey conducted by the Beijing Water Saving Management Center in 1999, which focused on residents’ awareness and behaviors.
### Table 7  The water using behavior of residents whether care about saving water

<table>
<thead>
<tr>
<th>Water use items</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brushing teeth</strong></td>
<td>Let water run constantly, use 6L water in 30 seconds</td>
<td>With cup, use water 0.2L each time</td>
</tr>
<tr>
<td><strong>Cooking</strong></td>
<td>Wash for a long time; Use clean water to wash vegetables and fruits directly</td>
<td>Use paper to clean oil and dirt; wash in hot water first, then in cool water; disconnect and control quantity of water used</td>
</tr>
<tr>
<td><strong>Cleaning toilet</strong></td>
<td>Common bowl with huge capability water case which is above 9L</td>
<td>Put bottles in water case to reduce capability, reuse the washing water or shower water for toilet</td>
</tr>
<tr>
<td><strong>Washing clothes</strong></td>
<td>Continuing the process watering and draining while washing, use 165L of water each time; too high water level and too much scour being used</td>
<td>Add dehydrating step and use 110L each time; reasonable water and scour level, concentrate to wash; reuse water</td>
</tr>
<tr>
<td><strong>Bath</strong></td>
<td>Bathe for a long time with the faucet open; with full water in tub</td>
<td>Running water discontinued and turn off the faucet when it is not necessary; with 1/3 or 1/4 water in the tube</td>
</tr>
<tr>
<td><strong>Washing face and hands</strong></td>
<td>Wash for a long time and keep the water running</td>
<td>Turn off when it is not necessary, and use basin</td>
</tr>
</tbody>
</table>

Data sources: Beijing Water-saving Management Center

According to the Beijing Water Saving Management Center’s survey conducted in May and June of 1999, about 80% of the residents surveyed understood the situation of the water shortage in Beijing, and 91% noticed the campaign conducted. However, because the price of water was still low, and accounted for only a small proportion of total expenditure, only 64% of household knew the unit price of water.

The situation had changed by 2005, as the price of water increased and awareness improved. By the end of 2005, almost all the residents understood the water shortage situation (about 99.1% of of3000 households), and about 95.5% of the residents clearly knew the price of water was 3.7 RMB/t. At the same time, about 90.9% of the residents would reuse water after washing clothes and vegetables, and from showering, for flowers, and for cleaning the floor. It clearly showed that the water reuse was a daily behaviour.
3.1.2 The long-term reactions to the water price increase

In the long run, the residents would buy and use water saving facilities or instruments.

Table 8 Options for residents to buy and use water saving facilities and instruments

<table>
<thead>
<tr>
<th>instruments</th>
<th>water saving options in the long run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap</td>
<td>Use water saving tap instead of the older ones</td>
</tr>
<tr>
<td></td>
<td>Instead all-round tap with 1/4 round tap</td>
</tr>
<tr>
<td>Bath Instruments</td>
<td>Using shower;</td>
</tr>
<tr>
<td></td>
<td>Use water saving shower tap</td>
</tr>
<tr>
<td>Washer</td>
<td>Use water saving washer</td>
</tr>
<tr>
<td>Toilet case</td>
<td>Use 6L water case instead of 9L;</td>
</tr>
<tr>
<td></td>
<td>Use 3/6 two water case</td>
</tr>
<tr>
<td>Toilet washing system</td>
<td>Recycling water being used for residential areas</td>
</tr>
</tbody>
</table>

Data sources: Beijing Water-saving Management Center

We used the data collected by the survey conducted by the Status and Trend of Residential Water Uses in Beijing, in the year of 2003, and the survey conducted by Beijing Statistic Bureau in 2005. It found that about 91.6% of households used the water saving tap, and 25.4% used water saving toilet facilities. While the survey conducted by Beijing Statistic Bureau in 2005 showed that it reached 93.2% and 66.8% respectively.
Data sources: Status and Tread of Residential Water Uses in Beijing (2003); Investigation of water using instruments among Beijing residents by Beijing Statistic Bureau (2005)

Fig 9. water saving instruments being used

3.2 The analysis of surveys conducted for 200 households

According to the survey conducted for the 200 households regarding their behaviors on using water, we can summarize the following results.

3.2.1 Residents care more about water quality

In the following table 9, when asked the following question: “What do you care about water most, its quality, price, quantity, or pressure?” 90% were concerned about water quality. This implies that as the price increased, residents cared whether the quality of water improved, which may also refer to their concern about whether services were improved while the price went up.
3.2.2 The attitude toward water price reform is closely related to the income

3.2.2.1 Low-income level group cares more about water price than the high-income level group

Also, in the summary table 9, it was clearly shown that about 50% of the lower income households, income lower than 1000 RMB/month/person, cared about price, and as income increased, the proportion decreased. For those with highest income level, above 5000 RMB, the proportion was 26.9%. This may imply that the water expenditure accounted for a larger proportion of income for the low-income family, and they cared more about price and the way charges were collected.

Table 9 Answers to the question “What do you care most about water?”

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>less than 1000</th>
<th>1000~2000</th>
<th>2000~3000</th>
<th>3000~5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondents numbers</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>number</td>
<td>30</td>
<td>50</td>
<td>50</td>
<td>27</td>
<td>23</td>
<td>180</td>
</tr>
<tr>
<td>Percentage</td>
<td>83.3%</td>
<td>89.3%</td>
<td>92.6%</td>
<td>96.4%</td>
<td>88.5%</td>
<td>90%</td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>number</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Percentage</td>
<td>5.6%</td>
<td>3.6%</td>
<td>7.4%</td>
<td>3.7%</td>
<td>7.7%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>number</td>
<td>18</td>
<td>24</td>
<td>17</td>
<td>10</td>
<td>7</td>
<td>76</td>
</tr>
<tr>
<td>Percentage</td>
<td>50.0%</td>
<td>42.9%</td>
<td>31.5%</td>
<td>35.7%</td>
<td>26.9%</td>
<td>38.0%</td>
</tr>
<tr>
<td>Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>number</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Percentage</td>
<td>5.6%</td>
<td>1.8%</td>
<td>1.9%</td>
<td>0</td>
<td>0</td>
<td>2%</td>
</tr>
</tbody>
</table>

Fig 10. Degrees of different income-level groups caring about water price
### 3.2.2.2 High-income group agrees more about water price than the low-income group

With regard to the question about whether water price reform is reasonable or not, an average of 51% answered “yes.” The high-income group agreed more about water price than low-income level group, in general.

In Fig. 11, among the respondents, 35.9% with the income lower than 2000 RMB agreed with the water price reform; 59.3% with income between 2000 and 3000 RMB agreed with the water price reform, while about 68.5% with income above 3000 RMB agreed with the water price reform. This may also be another indication of the financial constraints on low-income households.

![Fig 11. opinions regarding the water price reform (agree)](image)

### 3.2.3 Water price reform improves the resident’s awareness and behaviors regarding uses of water

The results of Table 10 show that by introducing price reform, a positive impact is generated in households and residents.
Table 10: The awareness regarding water resources and water uses

<table>
<thead>
<tr>
<th>NO.</th>
<th>Questions</th>
<th>Answer getting highest percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>If you think that it’s necessary to save water, what’s the reason:</td>
<td>The price of water is very high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 (3)</td>
<td>If you think the price of water is reasonable, what’s the reason:</td>
<td>Increasing the price of water encourages saving water</td>
</tr>
<tr>
<td>5 (5)</td>
<td>When did you start to care about saving water?</td>
<td>After the price increased several times</td>
</tr>
<tr>
<td>5 (4)</td>
<td>After several adjustments to the price of water, have you recognized the seriousness of the water shortage?</td>
<td>Yes</td>
</tr>
<tr>
<td>5 (4)</td>
<td>After several adjustments to the price of water, have you recognized the necessity to save water?</td>
<td>Yes</td>
</tr>
<tr>
<td>5 (7)</td>
<td>Are you certain that your improved awareness of saving water is the result of water price reform?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.2.3.1 The increase of water price encourage the household believe it is necessary to save water

In Fig. 12, in the answer to the question 4b, “If you think it’s necessary to save water, what’s the reason?” about 37.5%, 29.1%, and 7.7% with income lower than 1000 RMB, between 1000~2000 RMB, and above 5000 RMB, respectively, answered that the price of water is higher. This further confirms that the price of water is a major factor influencing the residents’ water use behavior. Meanwhile, we found that in lower income households there were larger reactions than in higher income groups.

Fig 12. The ratio of the answers to the high price of water implies it is necessary to save water
3.2.3.2 The residents believe price reform is reasonable as it also promotes water saving

In the answer to the question 5(3), “If you think that water price reform is reasonable, what’s the reason?” 86.3% think that is reasonable because it encourages residents to save water and improves the residents’ awareness of water resources availability and the desire to save water. The residents would accept the price increase because it can help save water resources.

Table 11 Answers to the impact on saving water by increase of the price of water

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>Lower than 1000</th>
<th>1000~2000</th>
<th>2000~3000</th>
<th>3000~5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>(2)</td>
<td>14</td>
<td>19</td>
<td>32</td>
<td>22</td>
<td>15</td>
<td>102</td>
</tr>
<tr>
<td>(3)</td>
<td>14</td>
<td>19</td>
<td>25</td>
<td>18</td>
<td>12</td>
<td>88</td>
</tr>
<tr>
<td>(3)/(2)</td>
<td>100.0%</td>
<td>100.0%</td>
<td>78.1%</td>
<td>81.8%</td>
<td>80.0%</td>
<td>86.3%</td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents; (2) Number of people who think that water price reform is reasonable; (3) Number of people who think the reform can encourage people to save water in (3)/(2).

3.2.3.3 Water price reform improves the awareness of saving water

In responding to the questions regarding when they realized and started to think about saving water, an average of 28.3% said it improved after major price adjustments in 2000, 2002, and 2003. 53.1% and 15.4% of the households with income lower than 1000 RMB and higher than 5000 RMB answered yes, respectively. This implies not only that the increase of price improves awareness on one hand, but also further confirms the different reactions and attitudes to the price of water and price reform.
3.2.3.4 Water price reform promotes awareness regarding the situation of the shortage of water resources in Beijing

In answer to the question, “After several adjustments of water price, have you recognized the seriousness of water shortage?” On average, 90.5% think that they have recognized the problem after several adjustments. This shows that awareness was improved, and it indicated that price reform would help save water; as the awareness is the first step necessary to save water.

Table 12 Number and proportion of answers that after the price reform, the water shortage problems being realized

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>lower than 1000</th>
<th>1000~2000</th>
<th>2000~3000</th>
<th>3000~5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>(2)</td>
<td>32</td>
<td>54</td>
<td>51</td>
<td>25</td>
<td>19</td>
<td>181</td>
</tr>
<tr>
<td>(2) / (1)</td>
<td>88.9%</td>
<td>96.4%</td>
<td>94.4%</td>
<td>89.3%</td>
<td>73.1%</td>
<td>90.5%</td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents; (2) Number of people who think that water shortage is serious.
3.2.3.5 Water price reform prompted the residents to conserve water

To avoid arbitrary conclusions, we also make it clear on the questionnaire that "price reform improves the water-saving awareness of residents," and an average of 53% think their higher willingness to save water is closely related to water price reform, while it is no surprise that lower income groups have a higher proportion (58.3%).

Fig 14. The proportion of answers to the question of whether water saving is closely related to a price increase

Among those respondents who think that the water price reform has no direct relationship with the awareness improvement, an average of 57% of the residents think that although it is not that closely related, price reform can affect awareness to a certain degree.

---

8 Would you make sure that your improvement of awareness of water saving is the result of water price reform?
Table 13 Proportions that think price reform can affect the awareness to a certain degree, although they do not think it is closely related

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>lower than 1000</th>
<th>1000 ~ 2000</th>
<th>2000 ~ 3000</th>
<th>3000 ~ 5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>17</td>
<td>25</td>
<td>25</td>
<td>13</td>
<td>13</td>
<td>93</td>
</tr>
<tr>
<td>(2)</td>
<td>10</td>
<td>10</td>
<td>17</td>
<td>10</td>
<td>6</td>
<td>53</td>
</tr>
<tr>
<td>(2)/(1)</td>
<td>58.9%</td>
<td>40.0%</td>
<td>68.0%</td>
<td>76.9%</td>
<td>46.2%</td>
<td>57.0%</td>
</tr>
</tbody>
</table>

Notes: (1) Number of residents who think that higher awareness of water has no direct relationship with price reform; (2) Number of people who think still the price reform would affect the awareness

3.2.4 Residents started to use water saving facilities and instruments

3.2.4.1 Residents begin using water saving instruments

As Fig.15 shows, on average, 55% of the respondents have installed water-saving toilets, 69.3% of respondents have installed water-saving taps, and 32.5% have purchased water-saving washing machines. This shows that the price reform of water resources did promote awareness of the residents and further encouraged the installation of water-saving facilities and instruments.
Fig. 15. the changes of the water saving facilities and instruments

3.2.4.2 Increase the reuse of water

As Fig. 16 shows, on average, 79.1% of the respondents reused water if possible, 44% have minimized the use of washing machines, and 29.3% changed their tub to a shower. This shows that the residents adopted water-saving ways where possible. This also implies that water price reform has played a key role in the change of the water use behavior.
3.2.4.3 The installation of water-saving devices, and reuse of water is closely related to residents’ income

The increased income of a family provides for the possibility of residents to buy and install water-saving devices. As income increases, it becomes feasible to buy relatively more expensive water-saving devices. However, from the figure, we can see that when income reaches a critical point, per capita monthly income of 5,000 RMB or above), this percentage will decline. This may imply that the water expenditure does not account for a large proportion of income and total expenditure of that group. Although the low-income group has a higher preference to buy and use water saving facilities, they may be constrained by their financial situation.

3.2.4.4 The water saving actions produce effect

In the 200 respondents, 171 answered the question, "How much water consumption can be reduced by introducing water-saving instruments and actions monthly?" the remaining respondents indicated, "Haven’t taken that into account." Fig. 17 shows that 95 respondents think that the adoption of water-saving measures can save about one ton of clean water, 56 respondents think that can save two tons of clean water,
and 20 respondents think that it will save more than three tons of clean water. If we consider the current monthly use of water, around 10 tons a month, the water-saving effect is very significant.

3.2.5 Attitude toward water price policy: most residents support the blocked pricing policy other than uniform pricing policy

3.2.5.1 Many residents believe that the current water price reform hasn’t considered the different affordability between rich and poor families

For the residents who answered the reason why they think the current price reform is not reasonable, an average of 92.1% indicated that the existing water price reform has not considered the different affordability between rich and poor families.

Table 14 The attitude of support for water price increase in a uniform way

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>Lower than 1000</th>
<th>1000~2000</th>
<th>2000~3000</th>
<th>3000~5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>(2) 17</td>
<td>23</td>
<td>16</td>
<td>1</td>
<td>6</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>(3) 15</td>
<td>23</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>(3)/(2) 88.2%</td>
<td>100.0%</td>
<td>93.8%</td>
<td>100.0%</td>
<td>50.0%</td>
<td>92.1%</td>
<td></td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents; (2) Number of people who think that water price reform
is unreasonable; (3) Number of people who think that the reform ignores the income gap between families.

3.2.5.2 Most residents do not support increase a water price in a uniform way in the future

In Fig. 18, with the attitude toward "if the price increases to 4 RMB / t", 36% of those surveyed residents answered "reasonable, but it can not be afforded", 27.5% answered "unreasonable", and only 27.5% "reasonable, because it can be afforded", and the remaining 9% respondents answered "do not care." In fact, the former two categories of respondents accounted 63.5% in total. Therefore, if the price increased in a uniform way, most residents would be against it, and, only a small portion (27.5%) would support it.

In general, residents’ answers to this issue are closely related with their income level. In Fig.19, the proportion that answer "reasonable, because it is affordable" increases as the household income increases; the proportion that answer “reasonable, but it can not be afforded" increases as the household income decreases; the proportion of that answer "unreasonable" for other reasons decreases as the household income increases; and the proportion of that answer "do not care" increases as the household income increases.
3.2.5.3 Most residents support the IBT price system reform

As shown in Table 15, 91% of respondents support IBT pricing policy, some people even wrote, "we should implement the IBT price system," as they disagree reason with the uniform pricing policy.
Table 15  Residents attitude toward IBT water pricing policy

<table>
<thead>
<tr>
<th>Income respondents (¥)</th>
<th>lower than 1000</th>
<th>1000~2000</th>
<th>2000~3000</th>
<th>3000~5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>(2)</td>
<td>30</td>
<td>51</td>
<td>51</td>
<td>28</td>
<td>22</td>
<td>182</td>
</tr>
<tr>
<td>(2) / (1)</td>
<td>83.3%</td>
<td>91.1%</td>
<td>94.4%</td>
<td>100%</td>
<td>84.6%</td>
<td>91%</td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents;  (2) Number of residents who support the IBT

3.2.6 Other observation: residents support the reform that increases the levy on the water resources fee and the sewage treatment cost

In the process of completing the questionnaire, many respondents took a closer look at the changes of the components of price. They would support the water fees and sewage treatment fee increases, and believe they are reasonable; and they doubt that the water supply cost increases. This shows that if a transparent process were to be used, for example, and an effective public hearing were to be held, those would improve the acceptability of price reform. It is very necessary to provide detailed financial information to the public and especially the water supply cost to the water company.

3.2.7 Media played an important role on improving water saving awareness

Survey results showed that the water saving publicity of media affects the awareness of water conservation. In Fig. 20, an average of 50% of the residents thought that they improved their water saving awareness by getting information from media. This shows that in the future the government should continue its efforts to promote the dissemination of information and public awareness via media.
3.3 Other factors affect the behaviors of residents

3.3.1 Continued growth of income

As mentioned above, in addition to water price, residents’ behavior will be affected by their income. In recent years, the income of households increased, although the annual growth rate declined.

As shown in Figure 21, the per capita income of urban residents increased from 1,787 RMB in 1990 to 17,653 in 2005. As income grew, households would buy and install more water using facilities which used to be only a luxury consumer goods, such as washing machines, dishwashers, toilets, baths, and so on. As Fig. 22 shows, the numbers of water related devices and facilities owned by 100 households increased largely since early the 1990s, for example the hot shower facilities increased from 17 in 1992 to 78.1 in 2001. The increase of income and living standards imply the further growth of water demand in the future.
3.3.2 Availability of water saving facilities and policies

With the implementation of water pricing policy and the policies regarding water saving facilities, more and more water saving facilities are being marketed and made available to residents.
3.3.3 The problems related to the use of revenues generated from the water pricing policy

Currently, as there is no an effective transparent process for the use of the water related charges, and residents also have doubt about whether the “engineering costs” (supply costs) are being used to improve the services provided by water company. In addition, although there are some regulations regarding the use of the wastewater treatment cost, however, the residents think that it is not transparent either, and such a situation may affect the introduction of pricing reform.

Residents care much about how the charges being used, sometimes, it will affect the residents to pay the charges on time. As the reform and frequent adjustment of water price, more and more residents concern about the uses of the charges. In the following table, that about 81% of the residents surveyed clearly stated that they do concern about the uses of the water charges, while about 58.5% of the residents would be affected about their payment for the charges.

Table 16 Residents’ concern the use of sewage treatment charges

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>Lower than 1000</th>
<th>1000～2000</th>
<th>2000～3000</th>
<th>3000～5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>(2)</td>
<td>33</td>
<td>46</td>
<td>44</td>
<td>26</td>
<td>13</td>
<td>162</td>
</tr>
<tr>
<td>(2)/(1)</td>
<td>91.7%</td>
<td>82.1%</td>
<td>81.5%</td>
<td>92.9%</td>
<td>50.0%</td>
<td>81.0%</td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents; (2) Number of people who concerns about the way of use the sewage treatment charges

Table 17 the payment will be affected by the way of use of the sewage treatment charges

<table>
<thead>
<tr>
<th>Income of respondents (¥)</th>
<th>Lower than 1000</th>
<th>1000～2000</th>
<th>2000～3000</th>
<th>3000～5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>(2)</td>
<td>26</td>
<td>35</td>
<td>32</td>
<td>14</td>
<td>10</td>
<td>117</td>
</tr>
<tr>
<td>(2)/(1)</td>
<td>72.2%</td>
<td>62.5%</td>
<td>59.3%</td>
<td>50.0%</td>
<td>38.5%</td>
<td>58.5%</td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents; (2) Number of residents who’s payment will be affected by the way of use sewage charges
Chapter 4  Econometric Analysis for the Domestic Water Demand

In order to study the welfare of residents, we conducted an empirical study of how demand played a role on the price of Beijing domestic water uses. By controlling demand to different income groups with price changes, we looked at the effects on the different groups, especially by income distribution. The study uses Beijing statistics related to domestic household water uses and analyzes the various factors’ impacts on water uses and demand by establishing the econometric models.

4.1  Theory and Methodology

4.1.1  The Almost Ideal Demand System (AIDS) AIDS Model

The Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980) and its successor the Quadratic Almost Ideal Demand System (QUAIDS) (Banks, Blundell and Lewbel 1997) are used in this study. They have also been used by a large number of authors interested in consumption analysis to establish consumer responses to price changes for nondurable goods such as food and clothes. The AIDS model gives an arbitrary second-order approximation to any demand system and provides a reasonably flexible representation of preferences. Deaton and Muellbauer (1980) show that it satisfies the axioms of choice, aggregates over consumers without a need to assume parallel Engel curves, and has a functional form consistent with known household budget data. The QUAIDS model is the extension of AIDS and the complete class of integrable quadratic logarithmic expenditure share systems. The QUAIDS model became necessary after it was observed that the empirical Engel curves (expenditure share as a function of income) were implicitly assumed in the forerunner to the AIDS system, the linear expenditure system or LES.

---

9 This study continues to use the methodology being applied by the CCICED study, Zhang Shiqiu, Tim Swanson, et al. 2006, which was mainly conducted by Ben Groom. In this study, we re-exam the previous study, and use one more year data (2004) to simulate

10 Parallel Engel curves (expenditure share as a function of income) were implicitly assumed in the forerunner to the AIDS system, the linear expenditure system or LES.
curves for certain goods exhibited curvature in the log of income, contrary to the restriction implied by the simpler AIDS model. In short, the QUAIDS model allows the expenditure share to be quadratic in the log of income rather than linear. This conforms to intuition by allowing goods in the demand system to be luxuries at some income levels and necessities at others.

These models of demand are derived as follows. They assume the following form for indirect utility, where $y_h$ is household income and $p$ is a vector of commodity prices:  

\[
\ln V = \left( \ln y_h - a(p) \right)^{-1} + \lambda(p)^{-1}
\]  

(1)

The functions $a(p)$, $b(p)$ and $\lambda(p)$ are all functions of the vector of prices and capture in a general way the nature of the response to price changes. In order to maintain flexibility in the estimated response these functions are usually represented in a flexible functional form. Deaton and Muellbauer (1980) characterize these responses as follows:

\[
a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j
\]  

(2)

\[
b(p) = \prod_{i=1}^{n} p_i^{\beta_i}
\]  

(3)

\[
\lambda(p) = \sum_{i=1}^{n} \lambda_i \ln p_i , \text{ where } \sum_{i} \lambda_i = 0
\]  

(4)

where $a_0$ is commonly interpreted as the subsistence level of expenditure (Banks, et al 1997) and $\alpha_i, \beta_i, \gamma_{ij}$ and $\lambda_i$ are the parameters to be estimated. It is easy to show that (1)-(4) yield Marshallian demands in budget shares form:

---

11 The indirect utility function represents individual utility as a function of income and prices and is derived from the utility maximization. The direct utility function, on the other hand, represents utility in terms of quantities of the commodities that affect individual welfare.
In theory, if the consumers’ utility are maximized then the following parameter restrictions will hold: $\sum_i a_i = 1$, $\sum_i \beta_i = \sum_i \lambda_i = 0$ and $\sum_i \gamma_{ij} = 0$ for adding-up, i.e. all expenditures add up to disposable income; $\sum_j \gamma_{ij} = 0$ for homogeneity, i.e. the consumers choice will not change if, for example, both prices and income double; and $\gamma_{ij} = \gamma_{ji}$ for symmetry, i.e. the cross price responses are symmetric. Some of these properties can be tested empirically.

The AIDS consists of (2), (3) and (5), with $\lambda_i = 0$, that is, without the quadratic expenditure term. Koundouri et al (2002) used QUAIDS to model residential water demand function in Cyprus. They then went on to compare the welfare outcomes arising from the movement of the system from one of the IBTs to a uniform marginal cost tariff. Here we use the AIDS model, the system of demand equations for which takes the following form for good $i$ and household $h$:

$$w_{ih} = a_i + \sum_j \gamma_{ij} \ln p_j + \beta_i [\ln y_{ih} - a(p)] + \prod_j \beta_j [\ln y_{ih} - a(p)]^2$$

(5)

We follow Koundouri et al (2002) and estimate one equation for water in the form shown in (6) above. Individual household characteristics are represented by a number of indicator variables drawn from the aggregated data. Other goods are represented as a Hicksian composite good, which allows estimation of (6) as a single equation.

Given the functional form of water demand that emerges from the AIDS, it is possible to obtain expressions for the price and income elasticity of demand for water (PED and IED). We will compare these to previous estimates in the literature and, of course,
they are crucial for the welfare analysis undertaken in the policy simulation. The expression for PED and IED are respectively:

\[
PED = \frac{1}{w_{ht}} \left[ \gamma_g - \beta_g \left( a + \gamma_g \ln p \right) \right] - 1
\]

(7)

\[
IED = \frac{\beta_g}{w_{ht}} + 1
\]

(8)

In addition to this important elasticity, estimation of the parameters in (6) allows us to represent the indirect utility function shown in equation (1) and hence to assess changes in the pricing policy for any of the goods considered in the demand system. In our case, we are interested in estimating the welfare impacts among different income groups of changes in the price of water and the schedule of tariffs that consumers of water are faced with. The policy simulation that we undertake is described below.

### 4.1.2 Policy Simulation and Welfare Analysis

Our policy simulation compares a number of proposed pricing policies for water in Beijing. A policy was proposed by Beijing in 2004 regarding implementing the Increasing Block Tariff, IBT pricing policy in Beijing. According to this policy proposal, the proposed IBT system will have 3 blocks, with the ratio of the price level at 1:3:5, with the first block price at 4.5 RMB/ton. The first block was set up for 12t/month per household to meet the basic needs, 12-16t/month per household for improving the life quality and over 16t/month as the third block to satisfy special consuming demand. The proposed IBT water pricing system for residential water can be summarized as the following figure:

---

13 For a complete discussion see Banks et al (1997) for the QUAIDS Deaton and Muellbauer (1980) for the AIDS.
We conducted the policy simulation for the following:

- **Impact of full cost uniform pricing**: We assess the welfare impact on different income groups of charging water at the current full cost uniform volumetric tariff of 7 RMB/m³. The 7 RMB/m³ is based on the information from the National Development and Reform Commission which is based on the cost of the water transfer project from the Yangtze river to Beijing. In 2007, the Ministry of Water Resources further confirms this.

- **Relative impact of 4 family IBT**: We compare the welfare impact of the uniform full cost pricing policy to that caused by the introduction of the 4 person family IBT tariff schedule described in Section 2.1 above.

- **Relative impact of 3 Family or lifeline IBT**: We compare both of the above pricing policies to the introduction of the 3 person family IBT described above.

Once we have obtained our estimates from the AIDS estimation we can define welfare measures to assess the impact of moving from one tariff system to another. In the single equation case, if we represent the baseline tariff structure as $P_2$ and the
proposed tariff structure as \( P_1 \) we can define 2 separate measures of welfare changes. Firstly, we define the Compensating Variation (CV) and secondly we define the Deadweight Loss (DW).

The CV can be defined as an expenditure index that measures the amount of income that an individual household would be willing to pay (WTA) (or willing to accept (WTA)) in order to keep the original tariff structure/level, \( P_2 \). This measure makes an implicit assumption about the consumers’ rights to the status quo: consumers have no rights to the status quo. This reflects the fact that water in Beijing is priced far below the cost to society on the one hand, and the nature of recent pricing legislation on the other. The CV measure gives the change in income required to keep utility at the same level as under the reference prices, measured at the reference prices.

From (1), Setting utility equal under each pricing policy we get:

\[
V(x_{1h}, P_1) = V(x_{2h}, P_2) \Rightarrow \ln x_{1h} - a(P_1) = \ln x_{2h} - a(P_2)
\]

where \( x_{1h} \) is the expenditure or income level required by household \( h \) facing prices \( P_1 \) in order to maintain utility at the level achieved under the reference price \( P_2 \). If we normalize \( P_2 = 1 \) and rearrange we get the expenditure index:

\[
\ln X_h = \ln \left( \frac{x_{1h}}{x_{2h}} \right) = \frac{a(P_1) + [b(P_1) - 1]\ln x_1}{b(P_1)}
\]  

(10)

Notice that for a price rise it is the case that \( x_{1h} = x_{2h} + \Delta x \). In fact, \( \Delta x \) represents the equivalent variation (EV). The CV measure is reflected by \( \ln X_h \). Figure 24 provides a graphic description of this measure. We measure this expenditure index at

\[\text{Note that when we come to measure the relative effects of uniform pricing versus the IBT schedules, some consumers will be better off under the IBT than under uniform pricing and hence will only be willing to accept compensation to avoid the change in the price schedule.}\]
the subsistence utility level, i.e., setting \( x_{2h} = 1 \). Using the equations above, and the fact that the expenditure share at subsistence level under the reference prices can be written as \( w_{2h} = a_0 + \gamma \ln P_2 \), the measure for CV can be written as:

\[
\ln X_h = (w_{2h} - 0.5\gamma \ln P_2)\ln P_2
\]

The DW measure is defined as the monetary value of the change in log utility resulting from a change in the price regime when income remains at the baseline level. That is:

\[
\ln W_h = \frac{\ln x_h - a(P_2)}{b(P_2)} - \frac{\ln x_h - a(P_1)}{b(P_1)}
\]

Using the functional forms for the functions of price described above gives us a measure of the DW index in terms of the parameters of the utility function and the prices faced by the individual households:

\[
\ln W_h = \frac{-0.5\gamma (\ln p)^2}{p^\beta}
\]

This effectively reflects the substitution effect caused by changes in relative prices, with the denominator adjusting this effect to account for the heterogeneity of preferences and it should not deviate from unity. Again, a graphic description of this welfare measure is shown in Figure 25 below. The Equivalent Variation of a price increase from \( P_2 \) to \( P_1 \) is defined by \( V(x_{2h} + EV, P_1) = V(x_{2h}, P_2) \) in the diagram below. The deadweight loss, which measures the effect of substitution between goods, is measured by \( V(x_{2h}, P_2) - V(x_{2h}, P_1) \)\(^{15} \).

\^[15] This diagram also shows how the indirect utility function represents the value of utility at the points of utility
4.2 Data Sources and Data Processing

The household data for 2002-2004 and the aggregated data of 1987-2004 have both cross sectional and time series qualities. The household level data provides total monthly expenditure and monthly expenditures on utilities, water and non-food commodities for this 24 month period for a sample of 1000 households (while it was 2000 households in 2004)\textsuperscript{16}. The aggregated data provides similar characteristics but at the level of the income quintile for a 16 year period. In short, we are presented with two panel datasets.

\textsuperscript{16}As described in Section 2.4 below, there is a certain amount of attrition of households over this period. Ultimately, only 600 households appear for the entire 24 months, the remainder being resampled.
The data is coming from the Beijing Statistic Data, and the Beijing Urban Household Income and Expenditure Survey (BIES), the collection of which is undertaken by the State Statistical Bureau of Beijing. The survey requires respondents to keep a daily expenditure diary for a full 12-month period. As with other surveys of household expenditures, the expenditure categories are numerous and detailed and include household durables as well as consumption items, incomes and numerous details concerning family members and characteristics of accommodation. Quantities are also recorded. Theoretically, the data is vetted for quality by an enumerator who visits each household once or twice a month.

The preliminary analysis was undertaken using annual published statistics over the period 1986-2004 which gave average expenditures and average household characteristics for income quintiles. Those aggregated data includes income, expenditure, household size, number of water consumption facilities (washing machines and showers), and expenditure on water, electricity, and other fuels.

In addition, the monthly household level data for 2002-2004 were used in order to undertake the welfare analysis in the most comprehensive manner possible. It contains data from 9 districts for the years 2002 to 2004, and includes monthly data from 2839 households. The data provides the information about the district of each household; the household’s total expenditure and non-food expenditure in each month; as well as the utility expenditure, water quantity and water expenditure for each billing period.

In order to analyze the water demand, this study also collects the real price of domestic water in Beijing. As not all the changes in the price of water happened at the beginning of the year, we use the months of the prices changes to average the price of that year. We further readjust the entire water price to the year 2000 level by using
Table 18 The nominal and real water tariff, Beijing 1986-2004 (RMB/ m\(^3\))

<table>
<thead>
<tr>
<th>Year</th>
<th>Data of the new price applied</th>
<th>Price 1 (before changes)</th>
<th>Price 2 (after changes)</th>
<th>Average annual price</th>
<th>CPI (2000 Prices)</th>
<th>Real Tariff (2000 Prices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Aug 1</td>
<td>2.90</td>
<td>3.70</td>
<td>3.233</td>
<td>102.46</td>
<td>3.155</td>
</tr>
<tr>
<td>2003</td>
<td>Jan 20</td>
<td>2.50</td>
<td>2.90</td>
<td>2.878</td>
<td>101.44</td>
<td>2.837</td>
</tr>
<tr>
<td>2002</td>
<td>Feb 1</td>
<td>2.00</td>
<td>2.50</td>
<td>2.458</td>
<td>101.24</td>
<td>2.428</td>
</tr>
<tr>
<td>2001</td>
<td>Feb 1</td>
<td>2.00</td>
<td>2.00</td>
<td>2.000</td>
<td>103.10</td>
<td>1.940</td>
</tr>
<tr>
<td>2000</td>
<td>Nov 1</td>
<td>1.60</td>
<td>2.00</td>
<td>1.667</td>
<td>100.00</td>
<td>1.667</td>
</tr>
<tr>
<td>1999</td>
<td>Nov 1</td>
<td>1.10</td>
<td>1.60</td>
<td>1.183</td>
<td>96.62</td>
<td>1.224</td>
</tr>
<tr>
<td>1998</td>
<td>Sep 1</td>
<td>0.80</td>
<td>1.10</td>
<td>0.900</td>
<td>96.04</td>
<td>0.937</td>
</tr>
<tr>
<td>1997</td>
<td>Dec 1</td>
<td>0.50</td>
<td>0.80</td>
<td>0.525</td>
<td>93.79</td>
<td>0.560</td>
</tr>
<tr>
<td>1996</td>
<td>April 1</td>
<td>0.30</td>
<td>0.50</td>
<td>0.450</td>
<td>89.07</td>
<td>0.505</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>0.30</td>
<td>0.300</td>
<td>0.300</td>
<td>79.81</td>
<td>0.376</td>
</tr>
<tr>
<td>1994</td>
<td></td>
<td>0.30</td>
<td>0.300</td>
<td>0.300</td>
<td>68.04</td>
<td>0.441</td>
</tr>
<tr>
<td>1993</td>
<td></td>
<td>0.30</td>
<td>0.300</td>
<td>0.300</td>
<td>54.48</td>
<td>0.551</td>
</tr>
<tr>
<td>1992</td>
<td>Jan 1</td>
<td>0.30</td>
<td>0.300</td>
<td>0.300</td>
<td>45.78</td>
<td>0.655</td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td>0.12</td>
<td>0.120</td>
<td>0.120</td>
<td>41.65</td>
<td>0.288</td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td>0.12</td>
<td>0.120</td>
<td>0.120</td>
<td>37.22</td>
<td>0.322</td>
</tr>
<tr>
<td>1989</td>
<td></td>
<td>0.12</td>
<td>0.120</td>
<td>0.120</td>
<td>35.32</td>
<td>0.340</td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td>0.12</td>
<td>0.120</td>
<td>0.120</td>
<td>30.13</td>
<td>0.398</td>
</tr>
<tr>
<td>1987</td>
<td></td>
<td>0.12</td>
<td>0.120</td>
<td>0.120</td>
<td>25.03</td>
<td>0.479</td>
</tr>
<tr>
<td>1986</td>
<td></td>
<td>0.12</td>
<td>0.120</td>
<td>0.120</td>
<td>23.05</td>
<td>0.521</td>
</tr>
</tbody>
</table>

The analysis of panel data has naturally received much attention in the literature (see e.g. Hsiao 2004 and Baltagi 2001). Panel data allows us to estimate the parameters of interest allowing for the likelihood that observations from particular households or income groups are likely to be similar in some way. Furthermore, panel data allows dynamic models to be estimated, and hypotheses to be tested, while allowing an assessment of the importance of unobserved individual or group heterogeneity in explaining observed behavior\(^\text{17}\). In our estimation procedure we exploit the panel nature of the data and employ panel data techniques in order to better explain the data.

\(^{17}\) The heterogeneity refers to the groups for which one has data, e.g. individuals, income groups etc. This depends upon the nature of the data and, for aggregated data such as ours, the assumptions one is willing to make regarding the nature of the groups.
generating process and obtain better estimates of the demand for water. We use the following econometric model in order to estimate the AIDS model described above on the household level data:

\[ w_{ht} = \alpha + \gamma_{ht} + \gamma_g \ln p_t + \beta_g \ln x_{ht} - a_0 \ln p_t - 5 \gamma_g \left( \ln p_t \right)^2 + u_h + \epsilon_{ht} \]

where \( w_{ht} \) is the expenditure share for the \( h \)th household in the \( g \)th income group at time \( t \), which in this case denotes the month. Notice that price only varies through time and not across households or income groups, while the parameters \( \gamma \) and \( \beta \) are deemed to vary across income groups, i.e., the model allows price responses and income responses differ across income groups.

The error structure in this model is assumed to consist of two components and to be additively separable. It is represented by the terms \( u_h \) and \( \epsilon_{ht} \). In sum, these terms capture the unobserved determinants of water demand. Unobserved individual heterogeneity is captured by the term \( u_h \), which is assumed to remain constant over time and yet be unique to the household. The term \( \epsilon_{ht} \) represents the purely random unobserved components that vary across time, such as macro economic shocks. It is important from the perspective of obtaining unbiased and consistent estimates of the parameters of the demand function to determine whether or not the time invariant individual specific effect is correlated with the observables. If this is so, then Generalized Least Squares is no longer an unbiased and consistent estimator for the parameters of interest since the explanatory variables are endogenous\(^{18}\). Happily, empirical testing can determine whether this is the case and the Fixed Effects estimator.

\(^{18}\) GLS is used in the analysis of panel data described by this model in order to account for the autocorrelation introduced by the time invariant term \( u_h \). This estimator is commonly referred to as the Random Effects estimator.
estimator can be used in order to overcome this problem. We follow the following procedure when estimating the AIDS system using the household level data:

- We estimate the Random Effects (RE) model under the assumption that there is no correlation between the household specific time invariant effect and the repressors: $E[X \mid u_h] = 0$

- We estimate a Fixed Effects (FE) model under the assumption that the individual specific effect is correlated with the explanatory variables: $E[X \mid u_h] \neq 0$

- We undertake a Hausman test in order to test the null hypothesis that $E[X \mid u_h] = 0$. If we fail to reject the null we use then we assume the RE model is more appropriate than the FE.

This procedure is common in the analysis of panel data (see e.g. Greene 2003, Hsiao 2004).

4.3 Estimation and Results

Firstly, by way of a preliminary analysis, we estimate a simple Marshallian demand curve using the data aggregated by income quintiles for the period 1987-2004. This allows us to assess the potential impact of recent policy reforms as well as obtaining preliminary estimates for price and income elasticity. We then move on to the estimation of the AIDS model, the policy simulation, and the exact welfare measurements derived from these estimates.

4.3.1 Engel Curves for water

One important restriction associated with the AIDS model is that, conditional upon the constant term, the expenditure share for goods is linear in the log of expenditure if the Engel curve is linear, and this suggests that the AIDS is enough to model domestic water demand pattern in Beijing. In order to test this nature of the Engel curve for
water we used the semi-parametric techniques to run a kernel regression of the budget share Engel curve, with price variables as parameters\textsuperscript{19}. It shows quite a good linear shape, as shown in Figure 25 below.

A downward slope of the Engel curve means the expenditure share of water consumption decreases with an increasing log of total expenditure, therefore suggesting domestic water falls into the category of necessity. This makes intuitive sense in Beijing where most of domestic water consumption is indoors rather than outdoors. Tap water use is mainly restricted to drinking, cooking, bathing, washing clothes, and similar purposes, as concluded by the survey conducted by Beijing Municipal Water Conservation Offices and Beijing Information Center in 2003.

Fig 25. Semi-Parametric Engel Curve for Domestic Water Expenditure Shares
4.3.2 Household incomes impose a significant impact on water demand, the PED, and the IED

This research conducts empirical studies about the Price Elasticity of Demand (PED) and Income Elasticity of Demand (IED). The study shows that the pricing policy can reduce demand of water.

The empirical finding throughout the world is that water is a necessary good, i.e. the income elasticity of demand lies between zero and 1; hence, it is likely that the negative impact of increasing water prices is likely to fall disproportionately upon the poor. IED are all small and positive except for the top 20% of households, which have negative but significant budget elasticity. These results are largely in accordance with other water demand studies and our intuition regarding water demand. It suggests that low-income households will tend to increase their consumption of water per capita as income increases increase. The extent to which water consumption increases with income declines as households become richer, reflecting the fact that there are physical limitations on the extent to which water use can be increased with income once prudence with regarding water consumption becomes less of an issue. That the IED for high-income groups is negative could reflect the facts that the higher income group is busier, has less time at home, and cooks less as they choose to have food outside. Such facts may introduce more substitute water use behaviors. In addition, the richer groups of Beijing do not have much luxury goods such as swimming pools and irrigated gardens, therefore the water demand for luxury uses is not significant.

PED is significant at the 1% level. The negative value of PED further addresses the feature of water as a necessity good and would show that it would be effective to introduce demand side management. In addition, the value of the PED for the first 4 groups is between 0~1 shows the rigidity of PED. On one hand, all income groups will respond to the changes of price, and on the hand, the higher value of the highest
income groups means that they have more opportunity to respond to the price changes as they may have more opportunity to reduce their luxury use of water, and to swiftly install water conservation facilities.

<table>
<thead>
<tr>
<th>Income groups</th>
<th>0-20% (lowest)</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100% (highest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IED</td>
<td>.4289904**</td>
<td>.2346334**</td>
<td>.1205664**</td>
<td>.0620632**</td>
<td>-.3194785**</td>
</tr>
<tr>
<td>PED</td>
<td>-.6617562**</td>
<td>-.862384**</td>
<td>-.7691349**</td>
<td>-.7701065**</td>
<td>-1.351054**</td>
</tr>
</tbody>
</table>

** means significant at 1% level.

4.3.3 Welfare Effects of Introducing Increasing Block Tariff (IBT)

We use the monthly water consumption data to conduct the analysis, while taking 2004 as the base year for future price reform.

4.3.3.1 Consumption Blocks chosen by consumers in the short-run

In the short run, the demand response is significant with the majority of households consuming within the first block of IBT. About 85% of first 3 groups will be end up at first block, while the number decreases from 81% to 77% for the 4th and 5th group.

<table>
<thead>
<tr>
<th>Income groups</th>
<th>of hhs in B1</th>
<th>of hhs in B2</th>
<th>of hhs in B3</th>
<th>Total</th>
<th>B1(%)</th>
<th>B2(%)</th>
<th>B3(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lowest 20%, i.e., 0-20%</td>
<td>245</td>
<td>18</td>
<td>24</td>
<td>287</td>
<td>85.365854</td>
<td>6.271777</td>
<td>8.362393</td>
</tr>
<tr>
<td>20%-40%</td>
<td>277</td>
<td>32</td>
<td>15</td>
<td>324</td>
<td>85.493827</td>
<td>9.876543</td>
<td>4.615384</td>
</tr>
<tr>
<td>40%-60%</td>
<td>266</td>
<td>20</td>
<td>24</td>
<td>310</td>
<td>85.806452</td>
<td>6.4516129</td>
<td>7.7419355</td>
</tr>
<tr>
<td>60%-80%</td>
<td>258</td>
<td>33</td>
<td>27</td>
<td>318</td>
<td>81.132075</td>
<td>10.377358</td>
<td>8.490566</td>
</tr>
<tr>
<td>highest 20%, i.e., 80%-100%</td>
<td>223</td>
<td>39</td>
<td>28</td>
<td>290</td>
<td>76.896552</td>
<td>13.448276</td>
<td>9.6551724</td>
</tr>
</tbody>
</table>
4.3.3.2 Consumption Blocks chosen by consumers in the long-run

Considering the long-run response of the household to price, the estimates show that all of them will end up in the first block.\(^20\)

Table 21 Consumption Blocks chosen by consumers in the long-run under the 4 Family IBT

<table>
<thead>
<tr>
<th>Income groups</th>
<th>of hhs in B1</th>
<th>of hhs in B2</th>
<th>of hhs in B3</th>
<th>Total</th>
<th>B1(%)</th>
<th>B2(%)</th>
<th>B3(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lowest 20%, ie, 0-20%</td>
<td>287</td>
<td>0</td>
<td>0</td>
<td>287</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20%-40%</td>
<td>324</td>
<td>0</td>
<td>0</td>
<td>324</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40%-60%</td>
<td>310</td>
<td>0</td>
<td>0</td>
<td>310</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>60%-80%</td>
<td>318</td>
<td>0</td>
<td>0</td>
<td>318</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>highest 20%, ie, 80%-100%</td>
<td>290</td>
<td>0</td>
<td>0</td>
<td>290</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

4.3.3.3 Impacts by Introducing LRMC pricing

The ratio of water expenditure in total expenditure of household will increase largely after introducing uniform pricing on long-run marginal cost (LRMC). In which, the ratio of the lowest group changes largely. Table 22 shows the ratio changes in both the short and long run. As the household will respond to the changes of prices in the end, the ratio will decrease. It should also noted that in the short run, the ratio is close the threshold level of 3% (Yu Fan 2006), while the ratio for higher income groups decrease more in a long run. This implies that the uniform pricing on LRMC will impose more burdens on the lower income groups and impose more impact on their welfare.

Table 22 Changes of Ratio of Water Expenditure in total expenditure (W) %

<table>
<thead>
<tr>
<th>Income group</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>w</td>
<td>.0146003</td>
<td>.0105505</td>
<td>.0089374</td>
<td>.0078833</td>
<td>.0049443</td>
</tr>
<tr>
<td>w (short run)</td>
<td>.02762219</td>
<td>.01996041</td>
<td>.01690859</td>
<td>.01491435</td>
<td>.00935408</td>
</tr>
<tr>
<td>w (long run)</td>
<td>.02426619</td>
<td>.01685999</td>
<td>.0145453</td>
<td>.01282735</td>
<td>.00718037</td>
</tr>
</tbody>
</table>

\(^20\) Although there are some inconsistences with our previous studies (CCICED 2005), it has no significant differences. This may be resulted by that we further include the data in 2004.
4.3.3.4 The welfare impacts of the 4 family IBT

The analysis on the welfare impact of the 4 family IBT shows that, in the short run, only the income increases, and the households can sustain their utility level, although the value is small compared with the income effects of the uniform pricing of the IBT. The main reason for this is that in a short run, some households still consume water in the 2nd and 3rd blocks, although most of them consume in the first block, so that is the reason the compensating variation is small.

In the long run, the households will respond to the changes of the price, and almost all the households will consume water in the first block. Under such situation, it means that all the households are subsidized, and the CV is negative, which means that the welfare of all the groups is improved. In addition, although CV is not that significant, the lower income groups have a higher CV value. This may be because the ratio of water expenditure of total expenditure for lower income groups is higher, and they may get more subsides.

Figures 26 and 27 also show the deadweight losses associated with the 4 family IBT. The deadweight loss measures the extent to which the individual households would be willing to swap the subsidy that is available for water consumption for a straight cash subsidy. In effect it is a measure of the welfare loss associated with the price distortion that the IBT introduces. It can be seen from Figure 26 that the welfare effect of the price distortion is highest at each extreme of the income distribution. In short, given all the other demands on the income of poor households, it would appear that they would value a cash subsidy introduced by the 4 family IBT more than the adjacent income quintiles.

In comparing Figures 26 and 27, it is clear that allowing for the heterogeneity
between seasons\textsuperscript{21} gives us quite a different welfare effect by income. The inclusion of the seasonal demand response is the more realistic of the two policy simulations with regard to estimating the welfare impacts. Doing so shows that the seasonal difference of water demand is larger for the rich residents rather than for the poor. In this case, it seems that the forthcoming pricing of increasing block tariffs is progressive and will reach the expected purpose of cross-subsidy from the rich to the poor.

Table 23 Compensating Variation (CV) of the 4 family IBT (short run)

<table>
<thead>
<tr>
<th>Income groups</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV (sr)</td>
<td>.0048513</td>
<td>.0018215</td>
<td>.0028511</td>
<td>.0041694</td>
<td>.0046157</td>
</tr>
</tbody>
</table>

Table 24 Compensating Variation (CV) of the 4 family IBT (long run)

<table>
<thead>
<tr>
<th>Income groups</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV (lr)</td>
<td>-.0074108</td>
<td>-.0051578</td>
<td>-.0043631</td>
<td>-.0036893</td>
<td>-.001694</td>
</tr>
</tbody>
</table>

Table 25 Dead Weight Loss of the 4 family IBT

<table>
<thead>
<tr>
<th>Income group</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWL</td>
<td>.000433</td>
<td>.0005095</td>
<td>.0004376</td>
<td>.0005446</td>
<td>.0009593</td>
</tr>
</tbody>
</table>

\textsuperscript{21} IBTs have been implemented in both developed countries such as Cyprus and the U.S., and developing countries such as Namibia and South Africa (e.g. Groom and van de Merwe 1999, Koundouri 2002, Billings and Agthe 1980). The common feature of these sites is that their climate is arid or semi-arid; they are subject to sporadic water shortages and widely fluctuating seasonal demands. The monthly data enables us to detect whether or not water demand is seasonal. We do this by including the dummy variable SUMMER for water which takes the value one for months June to September and zero otherwise.
Fig 26. The welfare impacts of the 4 family IBT with seasonal variation by income quintile (RMB/Month)

In summary, (1) in the short run, the income households would require in order to

Fig 27. The Welfare Effects of the 4 family IBT without seasonal variation by income quintile

In summary, (1) in the short run, the income households would require in order to
have the same level of welfare under the IBT is the same as under the uniform tariff. The black blocks represent the short-run impact upon the consumers and it can easily be seen that all income groups will suffer a welfare loss in the short-run since this expenditure index is positive for all income groups, however, the absolute value of such income effect is not that large if we compare the uniform pricing and IBT. The main reason for this is that in the short run, some of the households will continue to use water in the 2nd and 3rd block, therefore, the CV value of introducing IBT is not that large. (2) In the long run, as most of the households will respond to the pricing policy, almost all the households will stop using water in the first block. In fact, it means that all the households are being subsidized and the CV value is negative, which means that all the income groups are better off. Meanwhile, it can be observed that low-income groups are getting more compensation. This is mainly because the water expenditure accounts for a larger share in the total expenditure and it is getting more subsidies. (3) In addition, in the long run, the DWL is all positive for all income groups. This is under the condition that the household is responding to the price changes, and the welfare of all income groups is being improved by introducing IBT. As DWL measures the substitution effects, the DWL of higher income group is relatively larger, as the price elasticity of higher income groups is larger in the long run.

4.3.4 Burden of Water Saving and Cost Recovery

As the water bill accounts for a larger share in the total expenditure for the poor groups, their response to price changes is larger, which shows that the uniform pricing policy will constrain the water consumption of the poor groups more than the rich groups. According to our estimation, in the long run, the pricing policy will generate both substitution effects and income effects for households. By introducing LRMC (7 RMB/m³), the water demand will decrease by 12%-20%. Meanwhile, the medium and
lower income groups will reduce more; up to 50% compared with the higher income groups. That is, the first 3 lower groups will reduce their water demand more.

If an IBT pricing policy is to be introduced, which will follow the proposed 4 family member IBT, then almost all the income groups will use water in the 1st block as the average household size does not vary significantly across income groups in Beijing. With per capita consumption increasing with income this suggests that an IBT schedule will be a suitable instrument for ameliorating the impact of water pricing on low-income households. Indeed the current proposal for the IBT schedule for Beijing is the so-called ‘4 person family model’. It has been estimated that 91% of households in Beijing had 4 or less members, and 77% of households had 3 or less members. Therefore, the IBT based on 4 family members (12 m³/month for the first block) is enough and almost all the income groups will stop water demand in the 1st block. That is, under 4 family member IBT, all income groups are subsidized. A 3 family member IBT will improve the situation by shifting the burden from poor income groups to higher income groups, and only the highest group will use water that exceeds the 1st block, and the 2 highest income groups will take about 2-4 times of the water saving burden than that of the poor groups.
Chapter 5 **Findings and Policy Recommendations**

5.1 **Key Findings of the Study**

5.1.1 **Problems identified for Beijing’s Water Pricing Reform**

Beijing and other cities in China have made great progress regarding water price reform since the 1990s, especially since it started to focus on the pricing policy based on long-run marginal opportunity cost, and reflecting not only the water supply cost, but also the environmental cost and resources depletion cost.

However, some problems existed which should be given attention.

(1) The current price for residential water is still low compared with the long-run marginal opportunity cost of water in Beijing, which is about 52% of marginal opportunity cost (MOC). In addition, the price components of water resources charges (refers to the water depletion cost) are too low to reflect the water depletion and scarcity of water. Although the wastewater charges are almost equal to the wastewater treatment cost, they only reflect parts of the environmental cost of water uses. Such price structure constrains the acceptability of household acceptance of price reform and can not improve the awareness of water scarcity and environmental pollution, which impacts the full role played by pricing policy in regulating the household water use behaviors and supporting more efficient uses of water resources, while protecting the environment.

(2) The existing uniform pricing policy does not give full attention to the differences of the cost burden on lower and higher income groups, which constrains the introduction and implementation of water pricing policy.

(3) The uses of fees related to water is not very transparent, and that affects the household’s acceptation. The residents are concerned and worry about whether the fees being collected by the water supply company are being used to improve the
water supply capacity, sewage collection and sewage treatment facilities, and how the
water resources fees are being allocated. This opaque process impacts the households’
understanding and acception of the reasons for increases in the price of water and
sometimes, may even affect how they will pay the water bills.

(4) The availability of water conservation technologies and equipment is low, and the
quality of that equipment should be effectively regulated. The current market supply
of water conservation equipment can not meet the demand of households by quality
and type, which leaves few options for residents. Therefore, household water use
behavior is not as optimal as possible. (5) The rate of recycling water is very low in
Beijing residential areas; only a few residential areas have water-recycling facilities,
which affect the full use of water resources.

5.1.2 Reaction of Beijing Residents on Pricing Policy

(1) The residents are very concerned about water pricing reform

The attitudes are affected by the continuing reform of water pricing policy and
income level of the households. About 38% show their concern about water price
reform, in which, the low-income groups give more concern than the high-income
groups. About 51% think that the water price reform is rational, however, those with
higher income give responses that are more positive. Most of the people being
interviewed show their concern about the components of price; they would accept that
the increase of water price is rational only if it implies that there is an increase in
water resources charges and waste water treatment charges. They would question it if
the increase of water price meant there was an increase in water supply charges.
About 92.1% think that the current price system does not give concern to the cost
burden on different income groups, and about 91% showed their positive support to
IBT.
(2) Water pricing policy reform improves the resident’s awareness about water resources and water conservation

The investigation of the Beijing Municipal Water Conservation Management Center in May and June of 1999 showed that about 80% of the people interviewed had some understanding about the water scarcity in Beijing, while only 64% of the households knew the price on water.

With the more frequent increase of water price, the proportional price against total expenditure increased. In addition with education that is more frequent and with more water awareness promotion, the households gave more concern to domestic water uses. By the end of 2005, the same investigation surveyed about 3000 households and it showed that about 99% of the households understood the shortage of water resources in Beijing and about 95.5% knew what they paid for the price of water.

According to our survey, over 53% think that their awareness is closely related to water price reform.

(3) Water price reform improves the use of water conservation facilities and conservation behaviors

The reuse water and the use of water conservation facilities identify the changes in household water conservation behavior. Based on households surveyed, about 55% installed a water-conserving conservation lavatory, 32.5% of the households purchased a water-economical washing machine. About 79.1% of households would reuse water.

Even though the population growth rate decreased in Beijing the use of domestic water increased. Studies showed that income growth is the major driving factor in the growth of total water consumption, while the policy reform on pricing is the driving
factor in reducing the growth rate.

5.1.3 Household income imposes significant impacts on water demand, the PED, and the IED

This research conducted empirical studies about the Price Elasticity of Demand (PED) and Income Elasticity of Demand (IED). The study shows that the pricing policy can reduce demand of water.

Table 26 IED and PED of income groups

<table>
<thead>
<tr>
<th>Income groups</th>
<th>IED</th>
<th>PED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20% (lowest)</td>
<td>.4289904**</td>
<td>-.6617562**</td>
</tr>
<tr>
<td>20%-40%</td>
<td>.2346334**</td>
<td>-.862384**</td>
</tr>
<tr>
<td>40%-60%</td>
<td>.1205664**</td>
<td>-.7691349**</td>
</tr>
<tr>
<td>60%-80%</td>
<td>.0620632**</td>
<td>-.7701065**</td>
</tr>
<tr>
<td>80%-100% (highest)</td>
<td>-.3194785**</td>
<td>-1.351054**</td>
</tr>
</tbody>
</table>

** means significant at 1% level.

The empirical finding throughout the world is that water is a necessary good, i.e. the income elasticity of demand lies between zero and 1, hence it is likely that the negative impact of increasing water prices is likely to fall disproportionately upon the poor. IED’s are all small and positive except those for the top 20% of households, which have negative but significant budget elasticity. These results are largely in accordance with other water demand studies and our intuition with regard to water demand. It suggests that low-income households will tend to increase their consumption of water per capita as incomes increase. The extent to which water consumption increases with income declines as households become richer reflecting the fact that there are physical limitations on the extent to which water use can be increased with income once prudence with regard to water consumption becomes less of an issue. That the IED for high-income groups is negative could reflect the fact that the higher income group is busier and has less time at home, and cooks less as they...
choose to have their food outside the home. Such facts may introduce greater changes in water use behaviors. In addition, the richer groups of Beijing do not have many luxury goods such as swimming pools and irrigated gardens; therefore, the water demand for luxury use is not significant.

PED is significant at the 1% level. The negative value of PED further addresses the fact that water is a necessary good; it also shows that it would be effective to introduce demand side management. In addition, the value of the PED for the first 4 groups is between 0~showing the rigidity of PED. On one hand, all income groups will respond to the changes of price, while on the other hand, the higher value of the highest income groups means that they have more opportunity to respond to the price changes as they may have more opportunity to reduce the luxury use of water, and to swiftly deploy water conservation facilities.

5.1.4 Increasing Block Tariff system will help the conservation of water and improve the welfare and cost burden sharing

(1) In the short run, the demand response is significant with the majority of households consuming within the first block of IBT. About 85% of first 3 groups will end up in first block, while the number decreases from 81% to 77% for the 4th and 5th group (table 27).

Table 27: Consumption Blocks chosen by consumers in the short-run under the 4 Family IBT

<table>
<thead>
<tr>
<th>Income groups</th>
<th>of hhs in B1</th>
<th>of hhs in B2</th>
<th>of hhs in B3</th>
<th>Total</th>
<th>B1(%)</th>
<th>B2(%)</th>
<th>B3(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>245</td>
<td>18</td>
<td>24</td>
<td>287</td>
<td>85.365854</td>
<td>6.271777</td>
<td>8.3623693</td>
</tr>
<tr>
<td>2</td>
<td>277</td>
<td>32</td>
<td>15</td>
<td>324</td>
<td>85.493827</td>
<td>9.8765432</td>
<td>4.6153846</td>
</tr>
<tr>
<td>3</td>
<td>266</td>
<td>20</td>
<td>24</td>
<td>310</td>
<td>85.806452</td>
<td>6.4516129</td>
<td>7.7419355</td>
</tr>
<tr>
<td>4</td>
<td>258</td>
<td>33</td>
<td>27</td>
<td>318</td>
<td>81.132075</td>
<td>10.377358</td>
<td>8.490566</td>
</tr>
<tr>
<td>5</td>
<td>223</td>
<td>39</td>
<td>28</td>
<td>290</td>
<td>76.896552</td>
<td>13.448276</td>
<td>9.6551724</td>
</tr>
</tbody>
</table>

(2) Considering the household’s long run response to price, the estimates...
show that all of them will end up in the first block\textsuperscript{22}.

Table 28 Consumption Blocks chosen by consumers in the long run under the 4 Family IBT

<table>
<thead>
<tr>
<th>Income groups</th>
<th>of hhs in B1</th>
<th>of hhs in B2</th>
<th>of hhs in B3</th>
<th>Total</th>
<th>B1(%)</th>
<th>B2(%)</th>
<th>B3(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>287</td>
<td>0</td>
<td>0</td>
<td>287</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>324</td>
<td>0</td>
<td>0</td>
<td>324</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>310</td>
<td>0</td>
<td>0</td>
<td>310</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>318</td>
<td>0</td>
<td>0</td>
<td>318</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>290</td>
<td>0</td>
<td>0</td>
<td>290</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(3) The ratio of water expenditure as part of total household expenditure will largely increase after introducing uniform pricing on long-run marginal cost (LRMC), and the ratio of the lowest group changes most. Table 29 shows the ratio changes in both short and long run. In the long run, the ratio will decrease as the household responds to the changes of price. It should also be noted that in the short run, the ratio is close to the threshold level of 3% (Yu Fan 2006), while the ratio for higher income groups decreases more in a long run. This implies that uniform pricing on LRMC will impose more burdens on the lower income groups and will have more impact on their welfare.

Table 29 Changes of Ratio of Water Expenditure in total expenditure %

<table>
<thead>
<tr>
<th>Income groups</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>.01466003</td>
<td>.0105505</td>
<td>.0089374</td>
<td>.0078833</td>
<td>.0049443</td>
</tr>
<tr>
<td>Short run</td>
<td>.02762219</td>
<td>.01996041</td>
<td>.01690859</td>
<td>.01491435</td>
<td>.00935408</td>
</tr>
<tr>
<td>Long run</td>
<td>.02426619</td>
<td>.01685999</td>
<td>.0145453</td>
<td>.01282735</td>
<td>.00718037</td>
</tr>
</tbody>
</table>

(4) The analysis on the welfare impact of the 4 family IBT shows that, in the short run, only the income increase, and the households can sustain their utility level,

\textsuperscript{22} Although there are some inconsistencies with our previous studies (CCICED 2005), it has no significant differences. This may be resulted by that we further include the data in 2004.
although the value is small when compared with the income effects of uniform pricing of the IBT. The main reason for this is that in the short run, some households still consume water in the 2nd and 3rd blocks, although most of them are in the first block, and this is the reason the compensating variation is small.

In the long run, a household will respond to the changes price, and almost all the households will consume water in the first block. Under such a situation, this means that all households are subsidized, and the CV is negative, which means that the welfare of all the groups is improved. In addition, although CV is not that significant, the lower income groups have a higher CV value. This might happen because the ratio of water expenditure as a portion of total expenditure for lower income groups is higher, and they may get more subsides.

Figures 28 and 29 show the deadweight losses associated with the 4 family IBT. The deadweight loss measures the extent to which the individual household would be willing to swap the subsidy available through water consumption for a straight cash subsidy. In effect it is a measure of the welfare loss associated with the price distortion that the IBT introduces. It can be seen from Figure 28 that the welfare effect of the price distortion is highest at each extreme of the income distribution. In short, given all the other demands on the income of poor households, it would appear that they would value the cash subsidy introduced by the 4 family IBT more than the adjacent income quintiles.

In comparing Figures 28 and 29 it is clear that allowing for the heterogeneity between seasons gives us quite different welfare effects by income. The inclusion of the seasonal demand response is the more realistic of the two policy simulations with regard to estimating the welfare impacts. Doing so shows that the seasonal difference of water demand is more for the rich residents than for the poor. In this case, it seems
that the forthcoming pricing of increasing block tariffs is progressive and this will reach the expected purpose of cross-subsidy from the rich to the poor.

Table 30 Compensating Variation (CV) of the 4 family IBT (short run)

<table>
<thead>
<tr>
<th>Income groups</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV (sr)</td>
<td>.0048513</td>
<td>.0018215</td>
<td>.0028511</td>
<td>.0041694</td>
<td>.0046157</td>
</tr>
</tbody>
</table>

Table 31 Compensating Variation (CV) of the 4 family IBT (long run)

<table>
<thead>
<tr>
<th>Income groups</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV (lr)</td>
<td>-.0074108</td>
<td>-.0051578</td>
<td>-.0043631</td>
<td>-.0036893</td>
<td>-.001694</td>
</tr>
</tbody>
</table>

Table 32 Dead Weight Loss of the 4 family IBT

<table>
<thead>
<tr>
<th>Income group</th>
<th>0-20%</th>
<th>20%-40%</th>
<th>40%-60%</th>
<th>60%-80%</th>
<th>80%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWL</td>
<td>.000433</td>
<td>.0005095</td>
<td>.0004376</td>
<td>.0005446</td>
<td>.0009593</td>
</tr>
</tbody>
</table>
Fig 28. The welfare impacts of the 4 family IBT with seasonal variation by income quintile (RMB/Month)

Fig 29. The Welfare Effects of the 4 family IBT without seasonal variation by income quintile
5.2 Policy Recommendations

The fast growth of China’s economy imposes pressures on natural resources. Water shortage is a critical issue in China. Many studies demonstrate that the overuse of resources is closely related to the failure of pricing policy.

Pricing policy attracts a lot of attention and much effort is given: 1) to reforming pricing policy in order to provide the right price signals, and 2) to regulating water use behaviors, and 3) to reflect the scarcity of the water resources, and 4) to improving the efficient use of water resources and 5) to also reflect the environmental cost.

Beijing is a typical city of Northern China suffering from water shortage and water pollution. The annual average water resource available for Beijing is 3.63 billion m³. The per capita water resource available is only 300 m³, which is about 1/8 the average of China and 1/32 of the world average. The recently released report by Beijing EPB shows that 56 rivers of total 78 did not meet water quality standards, mainly because of the accelerated discharge of wastewater and the lack of water to recharge them due to the dry climate of recent years. In addition, by end of 2004 about 0.2 billion m³ of wastewater has to discharge to the river directly, yielding a wastewater treatment rate of only 22%.

Beijing has been practicing urban water pricing which can provide experiences and lessons to other urban areas. Since the late 1970s, water has been priced volumetrically in Beijing. Before 1997 the pricing policy in Beijing did not embrace the concept of full cost recovery, i.e. recovery of capital, operations and maintenance costs (O&M) and wastewater treatment. However, since 1997, the real price of water has increased sharply in Beijing. Furthermore, in 1998, an additional volumetric tariff for wastewater treatment was added. In addition to covering the cost of supply, the
water laws, policies and regulations are very much concerned with water saving and conservation methods and the protection of water resources. In this sense, pricing has also been promoted as a Water Demand Management (WDM) instrument.

Following the recent price hike on August 1, 2004, the current residential water tariff in Beijing is RMB 3.7/m³. The water price in Beijing reflects a number of different cost items. For example, in the latter part of 2003, the tariff was 2.9RMB/m³. This consisted of a water resource fee (for both surface and groundwater) of 0.6 RMB/m³, a sewage treatment fee of 0.6 RMB/m³, a tap water fee of 1.7 RMB/m³ to cover the fixed and variable (capital and O&M) costs of the water supply company, and a tax of 0.33 RMB/m³ paid to the Beijing municipality. This breakdown reflects the structure stipulated in China’s Price Law and the National Guidelines on Water tariffs. At present, the water price level in Beijing is the highest of all cities in China and recent price adjustments on the residential sector have focused their attention upon the sewage treatment fee and the water resource charge, rather than the tap water tariff. Although the price is increased, it is still subsidized.

About 20 cities in have introduced increased block tariff systems for water, and there are some proposals for introducing IBT to Beijing.

The following policy recommendation is provided based on the research findings of this project.

(1) Water pricing policy reform can be regarded as a macro level economic reform instrument. It can improve water use efficiency and help to prevent water pollution, which is regarded as a win-win solution for water resources. The current price level of water in Beijing is still very low compared with the long-run marginal cost. Therefore, it is quite necessary to increase the price.

(2) Environmental pricing policies should be developed around the concept of
marginal social cost of the use of the environmental resource concerned. Based on a current estimation, the long-run marginal cost of water in Beijing should be around 7 RMB/ton and that should serve as the basis for Beijing’s future water pricing policy reform. In addition, pricing policy should consider the impact on the poor and provide relief. Besides the price level, concerns should be given to the components of the water price, which should not only reflect the water supply cost, but also the water depletion cost and environmental cost associated with water uses. The current water resources charge is still too low to reflect the water depletion cost. The wastewater charges are about 0.9 RMB/ton, which just recover the wastewater treatment cost. It was projected that wastewater treatment cost would be around 1.25 RMB/ton by 2010. The wastewater charges should be equal or maybe higher than this level to ensure that the treatment cost is being recovered and to attract private investment into this market to provide environmental services.

(3) Higher prices for essential environmental services such as clean water may have significantly regressive impacts. A uniform pricing scheme may attain efficiency conditions at the margin, but it also gives rise to affordability problems for the poorer sections of the population.

(4) An increased block tariff system should be introduced instead of the uniform tariff for urban domestic water uses, to better reflect efficiency and equity considerations. The IBT can transfer the burden of water tariffs from poor to rich households and the evidence is that poor households will prefer this system to a uniform tariff system since their welfare can be increased by up to 2.7% of their income. As is the case in other water scarce countries like Chile, a comparison must be made of converting the lifeline tariff to a direct cash subsidy, which redistributes income to the poor, to, or other wealth distribution policies.
(5) For making water pricing policy, stakeholders’ participation approaches should be introduced. For example, the public hearing would provide opportunities for the stakeholders to state their interests and to ensure effective results, the public hearing process must be transparent and coupled with information disclosure.

(6) In order for residents to respond to price changes, alternative water conservation technology and facilities must be provided. (7) Although an IBT system can gain welfare improvement, some issues should be given concern:

- Revenue Sufficiency: The estimated elastic price response means that the vast majority of consumers end up in the lowest block of the IBT and lifeline tariff systems. The implication of this is that most households will be subsidized in their water consumption. Such a prediction is important for the Beijing tap water and sewage treatment companies since the tariff will fail to achieve cost recovery and hence the quality of the water supply (regularity, wastage, water quality etc.) will be hard to sustain or improve. Altering the various facets of the IBT could resolve the problem: the size of the first block and the size of the steps are important here. Based on the current research, it seems that the first block should be narrowed down, the 3 tons/person might be higher than the lifeline water needed. It also implies that a 3 block may not needed, that a two block is enough and it can greatly reduce the management cost.

- The incentives for a water supply corporation: the problems with IBT structures are well documented (Whittington and Boland 2000, Sterner 2003). Not least among these is the incentive effect that such a structure has upon water supply corporations whose objective is full cost recovery or private companies whose objective is to earn a return in capital. Sterner (2003) notes
that when an IBT is introduced, lets say for equity reasons such as those described above, since it is the poor who are generally subsidized by these tariff structures they frequently become a low priority for the water suppliers. For example, if water supply fails, a supplier who aims for cost recovery will be more inclined to fix a rich household’s supply before the poor household. Ultimately, the tariff structure introduced specifically to assist the poor perversely induces a lower quality service for poor households in the longer run. The potential for such disincentives, and the regulation required to remove them, needs to be tallied against the potential welfare enhancing effects described above.

- Subsidization of the rich: It should be made clear that the IBT system subsidizes all water consumers, rich and poor, for the initial units of water consumption. Furthermore, the subsidy is only available when households consume the full quota of water. Not all poor households will do this of course and hence they will not receive the full subsidy. In Chile, the lifeline tariff was replaced by a direct cash subsidy in certain urban areas. This was available as a refund to households upon application and was conditioned upon the water bill being more than 15% of household income. The analysis shows that in general there will be a preference for cash subsidies as measured by the deadweight loss.

i. Family size: It is frequently the case that poor households have larger families than richer households. Although family size appears to be relatively uniform in Beijing, it is likely that at the lowest extremes of the income distribution, households will lose out from a system based upon a 4 member family. This will be especially true where households share one metered connection.
ii. Seasonal Tariffs: given the clear importance of seasonal changes in demand indicated by the analysis: rich households respond to seasons more than the poor, and the imposition of seasonal tariffs might be an interesting means by which to induce conservation and target wealthy consumers.
## Annex 1: Summary of the Cities Introducing the IBT System in China

<table>
<thead>
<tr>
<th>City</th>
<th>Time</th>
<th>Rate</th>
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<tbody>
<tr>
<td>1 Xia Men</td>
<td>Jan 1, 1997</td>
<td>0.6 RMB/ton under 1.5 tons&lt;br&gt;1.4 RMB/ton for 15-20 ton&lt;br&gt;2.1 RMB/ton for over 20 tons</td>
</tr>
<tr>
<td>2 Ren Qiu</td>
<td>July 1, 2002</td>
<td>Life line water price being applied for 3 m³ person per month&lt;br&gt;2 times of life line water price for 3-5 M³&lt;br&gt;10 times of life line water price for over 5 M³</td>
</tr>
<tr>
<td>3 Jiao Zuo</td>
<td>July 1, 2003</td>
<td>First block is 12 m³ per household, with price of 1.2 RMB; 13-19 m³, with price of 1.80 RMB, above 20 m³ will be charged 2.4 RMB</td>
</tr>
<tr>
<td>4 Yin Chuan</td>
<td>Jan 1, 2004</td>
<td>IBT for domestic and non-domestic uses</td>
</tr>
<tr>
<td>5 Kun Ming</td>
<td>April 1, 2004</td>
<td>8 RMB for 10 tons of per household&lt;br&gt;2.45 RMB for 11-15 tons;&lt;br&gt;3.1 RMB for 16-20 tons&lt;br&gt;3.75 RMB for 21 above</td>
</tr>
<tr>
<td>6 Wen Zhou</td>
<td>May 1, 2004</td>
<td>3 RMB for under 8 tons per household&lt;br&gt;4.5 RMB for 8-14 tons&lt;br&gt;6 RMB for over 14 tons</td>
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<tr>
<td>7 Zheng Zhou</td>
<td>April 1, 2005</td>
<td>IBT</td>
</tr>
<tr>
<td>8 Qing Dao</td>
<td>June 1, 2005</td>
<td>1.6 RMB for 5 tons per household&lt;br&gt;2.5 RMB for over 5 tons</td>
</tr>
<tr>
<td>9 Qing Huang Dao</td>
<td>Dec 1, 2005</td>
<td>1.74 RMB for 3.5 tons per person&lt;br&gt;3.48 RMB for 3.5-5 tons&lt;br&gt;17.4 RMB for over 5 tons</td>
</tr>
<tr>
<td>10 Guang Zhou</td>
<td>Jan 1, 2006</td>
<td>1.32 RMB for 22 tons per household&lt;br&gt;1.98 RMB for 23-30&lt;br&gt;2.64 for over 30 tons</td>
</tr>
<tr>
<td>11 Zhu Hai</td>
<td>Jan 2006</td>
<td>1.38 RMB for under 15 tons&lt;br&gt;1.85 for 15-23 tons&lt;br&gt;2.35 for over 23 tons</td>
</tr>
<tr>
<td>12 Wu Han</td>
<td>May 1, 2006</td>
<td>3 steps IBT, With ratio of 1 1.5 2</td>
</tr>
<tr>
<td>13 Ning Bo</td>
<td>July 1, 2006</td>
<td>2.1 RMB for 17 tons&lt;br&gt;2.93 RMB for 18-30&lt;br&gt;3.75 RMB for over 30 tons</td>
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<tr>
<td></td>
<td>City</td>
<td>Date</td>
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<td>14</td>
<td>Nan Jing</td>
<td>July 1, 2006</td>
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<td>15</td>
<td>Fo Shan</td>
<td>Aug 10, 2006</td>
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<td>16</td>
<td>Lang Fang</td>
<td>Sep 20, 2006</td>
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<td>18</td>
<td>Xin Xiang</td>
<td>Nov. 1, 2006</td>
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<td>19</td>
<td>Wei Hai</td>
<td>Jan 1, 2007</td>
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<tr>
<td>20</td>
<td>Jin Zhong</td>
<td>April 1, 2007</td>
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References:


29. Deaton, Angus, John Muellbauer. An Almost Ideal Demand System. The


44. Gaudin, Sylvestre, Transparent Prices for Municipal Water: Impact of Pricing and


74. Kolokytha, E.G., Y.A. Mylopoulos, A.K. Mentes, Evaluating Demand


87. Muellerbauer, J., Community Preferences and the Representative Consumer.


147. Wichelns, D., L. Houston, D. Cone, Economic Incentives Reduce Irrigation


