Adoption of increasing block tariffs (IBTs) among urban water utilities in major cities in China

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ABSTRACT
Increasing block tariffs (IBTs) have been officially endorsed by the Chinese government since 1998, but by the end of 2013, fewer than half of the country's 36 major cities had adopted IBTs as the tariff structure for their water utilities. Our study examines the main factors affecting these cities' decisions on whether or not to adopt IBTs, considering both general characteristics of the cities and characteristics of their water utilities. A discrete-time hazard model is used for empirical analysis. Results show that factors most likely to affect a major city's decision on IBT adoption include the city's economic development as measured by growth rate of GDP; changes in the relative importance of the domestic water sector; the city's wastewater treatment rate and leakage rate; and business structure of the water utility.

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1. Introduction

In the water sector, a key challenge is how to meet economic, financial, environmental, and social objectives simultaneously through pricing mechanisms (Dalhuisen et al. 2003). Increasing block tariffs (IBTs) may appear attractive to water utilities in developing countries confronting a difficult trade-off between financial and social objectives, because IBTs may help to keep piped water services affordable as water consumption in the first block is priced low, while financial objectives can be achieved by charging incrementally higher prices for higher levels of consumption above that baseline. As a result, IBTs have been adopted by an increasing number of water utilities in developing countries around the world. Recent information from the Water Tariff Survey by Global Water Intelligence (GWI) indicates that IBTs were used in 51 percent of 185 water utilities in developing countries in 2013, as compared to 35 percent in 2007.

In China, the use of IBTs has been a part of national government policy in response to widespread water shortage problems experienced in many cities. It is a widely held belief that water consumption level is too high due to low pricing, and that charging consumers higher prices as their consumption rises could provide an incentive for water conservation (State Council 2000, State Planning Commission et al. 2000). Since 1998, the adoption of IBTs has been among the top priorities of national water policy in China. In 2002, it was expected in Circular on Propelling the Reform of City Water Price that all utilities in its 36 major cities should shift to IBTs by 2003.2

Despite the strong commitment and persistent efforts of the national government, the actual adoption of IBTs by water utilities in major cities in China has been much slower than expected. By the end of 2013, fewer than half of the 36 major cities had adopted IBTs (see Figure 1). Why has the adoption of IBTs among the major cities been so much slower than expected? Why did some cities adopt, while others resisted? What made a city decide to shift to an IBT structure at a particular time?

Our study aims to shed some light on these questions by presenting an empirical analysis of IBT adoption in major cities in China between 2002 and 2013. Because the national government policy was the same for all cities, the main differences in their adoption of IBTs may have been driven by existing characteristics of individual water utilities as well as by characteristics of the localities in which they operate. Our analysis employs a discrete-time hazard model to examine how various water utilities and city characteristics affected the major city governments' decisions on shifting to IBTs.

Our intentions here are threefold. First, while the case for adopting IBTs seems quite compelling in theory, there are only a few studies on the factors determining adoption of IBTs in practice (Hewitt 2000, Reynaud et al. 2005, Montginoul 2007, Boyer et al. 2012). That all cities in China were urged to shift to IBTs from linear tariffs, and that cities only gradually adopted IBTs, provided a unique opportunity to identify the key factors that may have determined the adoption of IBTs. To our knowledge, our study is the first to use survival analysis and city-level panel data to empirically investigate IBT adoption. Second, the results of our analysis...
China’s 36 major cities (Zhong and Mol 2010). By March 2014, the average CPI-adjusted domestic water tariff in these cities was around CNY 2.73/m³, as compared to about CNY 1.36/m³ in 2000, with an average annual growth rate of 5.5%.

This substantial increase in water tariffs has been the subject of intense debate and a source of tension in many cities in China. However, current water tariffs in China are still considerably lower than the cost-recovery level, even for operation and maintenance costs (Browder et al. 2007). According to the National Development and Reform Committee, the average water treatment charge in the big cities is equivalent to two-thirds of the treatment cost, resulting in a shortage of investment in wastewater treatment. More importantly, many Chinese cities have grown exponentially in area and population in the same three decades, further increasing the gap between supply and demand.

IBTs have been regarded as a key component of water tariff reform by the national government in China, especially in response to water shortage problems, with the expectation that water tariffs above “lifeline” minimum level would send strong signals to consumers about the scarcity of water and induce more conservation and efficiency in water use (State Council 2000, State Planning Commission et al. 2000, 2002, General Office of the State Council 2004, National Development and Reform Commission and Ministry of Housing and Urban-Rural Development 2013).

IBTs were first introduced as alternative water tariff structures to encourage water conservation in the national government’s Regulations on City Water Price, issued in 1998, and officially endorsed as the pricing mechanism of choice in 2000 through its Circular on Enhancing Water Conservation for Urban Water Supply and Prevention of Water Pollution. In 2002, an ambitious target was set in Circular on Propelling the Reform of City Water Price, directing water utilities in major cities to adopt IBTs by 2003.

Technical guidelines for implementing IBTs have been provided in several policy documents, such as Circular on Improving the Regulation Work of City Water Price (2009) and Decision on Propelling
The Water Reform and Development (2011), which state and clarify the general requirements for water price adjustment, adjustment procedures, pricing methodology, price composition, protection to low-income households, and communication tactics.

The national government’s continuing determination to achieve the adoption of IBTs is clearly shown in Guidance on Promoting Complete IBTs Structure for Urban Domestic Water Use (2013), which again sets a timetable for the adoption of IBTs. In this instance, all cities at county-level and above should have fully adopted IBT structures in the domestic water sector by the end of 2015, and towns with adequate conditions should also adopt IBTs.

Despite strong commitment and persistent efforts by the national government, the adoption of IBTs has been much slower than expected. By the target compliance deadline of 2003, only five cities had adopted IBTs, and by the end of 2013, only a total of 16 out of the 36 major cities had done so. Our paper aims to find the reasons for the slow adoption and the factors that affect the decision making.

2.2. Procedures of water price adjustment

Hall and Hanemann (1996) and Hall (2000) elaborated the process in which an IBT design based on marginal cost was chosen over an embedded cost rate design in Los Angeles, California. In China, IBT adoption and other water price adjustments also have to go through formal procedures before implementation. A simple review of the IBT adoption procedures in China would reveal the process of decision making and provides guidance for selecting the list of variables to be used in analysis. Current procedures are created by PRC Price Law (1997) and further detailed by Regulations on City Water Price (1997). Although not cast in stone, the procedures below have been followed by most cities, as suggested by Zhong and Mol (2008).

First, the water utility has to prepare the IBT pricing structure and submit it to the local government price authority and water bureau, which suggests that it is the water utility that initiates the IBT adoption. Water utility characteristics such as water management efficiency and type of business structure, and local conditions such as metering rate, wastewater treatment rate, the pressure to supply enough water to meet escalating demand, and local constraints on water resources would affect a water utility’s decision on whether to initiate an IBT adoption plan.

Second, the local government price authority is empowered to organize public hearings for adopting the IBT pricing structure. Although the form of and participants in public hearings are still heavily debated (Zhong and Mol 2008), in principle, local delegates from People’s Congress, People’s Political Consultative Conference, other governmental departments, and water users should be invited by the price authority to participate the hearings. If the pricing plan is passed, it will be submitted to the local government for final decision-making. Otherwise, it will not be submitted, and the water utility has to prepare a new pricing plan and resubmit the new one to the local government price authority and water bureau. A plan could be approved if a majority of delegates vote in favor of it. Apparently, the connection between water utility and local government price authority, the political influence of domestic users, and social resistance to water price adjustment would affect the outcome of public hearing on IBT adoption.

Third, it is the local government that makes the final decision on whether to adopt an IBT pricing structure. Once the new pricing plan is approved by local government, it has to be submitted to a higher-level government price authority and water bureau for recording and supervision. In addition, the local government has to announce the new pricing plan to the public before implementation. Factors such as local economic development level and social resistance to water price adjustment would be taken into account by the local government when making the final decision.

3. The discrete-time hazard model

Assuming that all major cities that had not adopted IBTs for their domestic water sectors by 2002 were “at risk” of doing so during the interval selected for study (2002-2013), we conduct a survival analysis to investigate how various water utilities and city characteristics affected individual cities’ decisions to make the shift. Since only yearly records are available, we estimate a discrete-time hazard model of the probability of adopting IBTs, using methods described in Prentice and Gloeckler (1978), Singer and Willett (1993), and Jenkins (1995). The same method had been applied previously to estimate the probability of transiting from public to private provision of water service in Argentina (Galiani et al. 2005).

We index the cities in the sample by i = 1,...,n. A city started in an initial state, non-IBT status, and was observed to exit the state either by adopting an IBT structure or by being censored when the sample period ended. The passage of time is indexed in terms of a set of positive integers: t = 2002 is the first year in which our sample started, and is the same for all cities studied; t = ti is the year in which the city was last observed in the sample. For uncensored cities, ti is the first year of IBT adoption. For censored cities, ti is 2013, the last year of sample period.

The discrete-time hazard rate of city i in year t, given that the city did not adopt IBT prior to t, can be written as

\[ h_{it} = \Pr (T_i = t | T_i \geq t; X_{it}) , \]

where \( X_{it} \) is a vector of regressors which can vary with time and \( T_i \) is the first year of IBT adoption. For uncensored cities, \( T_i \) falls into the sample period, so it can be observed. For censored cities, since IBT adoption did not take place during the sample period, \( T_i \) is unobserved.

In the case of uncensored cities, the probability that the city adopted IBT in year \( t_i \) is

\[ \Pr (T_i = t_i) = h_{it} \prod_{k=1}^{t_i-1} (1 - h_{ik}). \]

In the case of censored cities, the probability that the city adopted IBT after year \( t_i \) is

\[ \Pr (T_i > t_i) = \prod_{k=1}^{t_i-1} (1 - h_{ik}). \]

Assume that individual cities in the sample are independent. Define the event-history indicator \( y_{it} \). If city \( i \) is censored, all instances of \( y_{it} \) are equal to zero. If city \( i \) is not censored, all instances of \( y_{it} \) are equal to zero except for the \( y_{iti} \), which is equal to one. The likelihood function is
Table 1. Sample statistics in 2002 and 2013.

| Variables | 2002   | 2013   |
|-----------|--------|--------|
| Percentage of cities that adopted IBTs | 0.029  | 0.412  |
| Total water supply (10,000 m$^3$) | 48957  | 62643  |
| Lagged growth rate of total water supply | −0.010 | 0.026  |
| Ratio of domestic water consumption over total water supply | 0.424  | 0.416  |
| Lagged change in ratio of domestic water consumption | 0.022  | 0.004  |
| Leakage rate of public water supply | 0.151  | 0.162  |
| Wastewater treatment rate | 0.451  | 0.877  |
| Utility having FDI | 0.176  | 0.324  |
| Utility having been restructured | 0.294  | 0.853  |
| Provincial average water resource per capita (m$^3$) | 6454   | 6454   |
| Times of water price change from 2000 to $t−1$ | 0.412  | 3.353  |
| Rate of water price change from 2000 to $t−1$ | 0.101  | 1.206  |
| Real GDP per capita (yuan) | 18639  | 84587  |
| Lagged growth rate of real GDP per capita | 0.105  | 0.127  |
| Observations | 34     | 34     |

Notes: Sample statistics are calculated based on major cities with Shenzhen and Xiamen excluded.

* Variables that capture the growth rate or change from $t−2$ to $t−1$, $t = 2002, ..., 2013$.

† Provincial average water resource per capita is the same in 2002 and 2013, as it is the average of provincial water resource per capita 2003–2013.

\[
L = \prod_{j=i}^{n} \prod_{s=1}^{t} h_{is} (1 - h_{is})^{(1-y_{is})}.
\]

\[
h_{it} = \frac{1}{1 + e^{-C(t)-X_{it}\beta}}.
\]

The commonly used specification for the hazard rate, $h_{it}$, is the logistic one (Prentice and Gloeckler 1978, Singer and Willett 1993, Jenkins 1995):

\[
h_{it} = 1 - e^{-x_{it}^T\beta}.
\]

In both specifications, $C(t)$ is the baseline hazard function, which is common to all cities, but flexible across years. The two specifications are very similar, and the logistic model converges to a proportional hazard model as the hazard rate becomes small (Jenkins 1995).

Substituting either logistic hazard rate or complementary log-log hazard rate into Equation (4) and maximizing the likelihood generates the estimates of $\beta$, whose signs reveal the effect direction of utility and city characteristics on the probability of adopting IBTs.

4. Data

Panel data on the pricing structures across 36 major cities in China between 2002 and 2014 were gathered from *Price Yearbook of China* and website of the water group or water bureau in each city. Data on water utilities and city characteristics were extracted from *China Urban Construction Statistical Yearbook, China Statistical Yearbook on Environment, China Statistical Yearbook, and Price Yearbook of China.*

We assume that a city’s decision to adopt IBT was made on a yearly basis. As the final decision was made before announcement to the public, the announcement date is taken as the first year of IBT adoption.

We use log of total water supply to capture whether the volume of water supply in a given year affected the adoption of IBTs. To capture the effect of the pressure to supply enough water to meet escalating demand, the growth rate of total water supply from $t−2$ to $t−1$ is controlled for, similar to Galiani et al. (2005). We use ratio of domestic water consumption over total public water supply to measure the relative importance of the domestic water sector in the public utility of the city, which also serves as a proxy for the political influence of domestic users, as in Madhoo (2004). The change of the ratio from $t−2$ to $t−1$ is controlled for to capture the impact of lagged change in the relative importance of the domestic water sector. We construct these lagged variables for two reasons. First, the decision to adopt an IBT structure is more likely to be a response to a lagged change than to a contemporaneous change, as it takes time for a change to become felt. Second, adopting an IBT structure itself may contribute to the changes in these variables.

Leakage rate in the public water supply is a measure of the management efficiency of a public utility. High leakage rate means that a large proportion of water is wasted from production to consumption, which suggests low management efficiency. Since the implementation of IBTs would be accompanied by regular and accurate tracking of water consumption, leading to the exposure of a utility’s management efficiency, a utility with low efficiency might be reluctant to opt in IBTs in order to avoid the public scrutiny.

In line with *Regulations on City Water Price* (1998), water price should represent the full costs of water production. However, it is possible that a city with more sophisticated wastewater treatment facilities has higher revenue requirements and is more likely to adopt an IBT structure, as wastewater treatment fee is part of final water price, and in many cities, water supply and wastewater treatment are two businesses within one water group. We control for wastewater treatment rate to capture this effect.

To control for the impact of the water utility’s type of business structure, we use two indicators: utility having foreign direct investment (FDI), and utility having been restructured. Here restructuring means that the water utility is detached from the water bureau or any other government sectors and restructured into a limited liability company. The utility’s type of business structure reveals its connection with local government and its independence. A utility having FDI and (or) having been restructured is likely to have more control on water pricing.

Information on city-level water resources is not available from public sources. Alternatively, we use average volume of provincial water resource per capita from 2003 to 2013 to reflect the degree of water scarcity. We do this for two reasons. First, water resource was not reported until 2003. Second, volume of water resource varies across years, and we believe it was the long-run volume of the water resource instead of the short-run volume that affected a city’s decision on whether to adopt an IBT structure.

To capture social resistance to water price adjustment, we control for the times and the rate of water price change that a city experienced from 2000 to $t−1$. We choose 2000 as the starting year, as that is the earliest year that water prices are available. The
Table 2. Discrete-time hazard estimate of the likelihood of adopting IBTs in major cities.

| Independent variables | logistic | cloglog |
|-----------------------|----------|---------|
|                       | coeff/s.e. | coeff/s.e. |
| Log of time trend      | 1.989 (1.627) | 2.037 (1.587) |
| Log of total water supply (10,000 m³) | 0.787 (0.629) | 0.720 (0.596) |
| Lagged growth rate of total water supplya | 3.665 (2.727) | 3.639 (2.553) |
| Ratio of domestic water consumption over total public water supply | −5.942 (4.695) | −5.765 (4.543) |
| Lagged change in ratio of domestic water consumption over total public water supplya | −6.266*** (2.392) | −6.045*** (2.232) |
| Leakage rate of public water supply | −11.95** (5.833) | −12.01** (6.119) |
| Wastewater treatment rate | 4.422* (2.327) | 4.086* (2.184) |
| Utility having been restructured | −1.945** (0.946) | −1.920** (0.929) |
| Utility having FDI | −1.795* (0.921) | −1.808** (0.899) |
| Log of average water resource per capitab | −0.0798 (0.342) | −0.131 (0.303) |
| Times of water price change from 2000 to t − 1 | 0.334 (0.532) | 0.371 (0.541) |
| Rate of water price change from 2000 to t − 1 | −1.401 (1.596) | −1.494 (1.667) |
| Log of real GDP per capita | −1.403** (0.673) | −1.361** (0.640) |
| Lagged growth rate of real GDP per capitaa | 0.520** (0.229) | 0.527** (0.240) |
| Constant | 1.917 (7.161) | 2.592 (6.387) |
| Observations | 321 | 321 |

Notes: *significant at 10%; **significant at 5%; ***significant at 1%; Standard errors clustered at city level are in parentheses.

a Variables that capture the growth rate or change from t − 2 to t − 1, t = 2002,…, 2013.
b Provincial average water resource per capita is the same in 2002 and 2013, as it is the average of provincial water resource per capita 2003–2013.

reason for using t − 1 instead of t is that if the city adopted an IBT structure in t, the price adjustment in year t was likely to be part of its adoption scheme, while t − 1 was not affected. Social resistance is likely to have two opposite effects on IBT adoption. On the one hand, cities experiencing more frequent or larger magnitude of water price adjustment would encounter more resistance from the demand side and might have to postpone IBT adoption as a consequence. On the other hand, those cities may resort to IBT adoption rather than ordinary price adjustment, as once an IBT structure is built up, the water price of the second or higher blocks can be raised farther without arousing public attention, as long as the price of the first block, which the majority of the population is paying, is kept untouched.

Log of real GDP per capita and growth rate of real GDP per capita from t − 2 to t − 1 are used to measure the change in economic development that a city experienced. As with changes in water supply and the relative importance of domestic water consumption, the lagged growth rate of economic development from t − 2 to t − 1 is constructed.

A panel data set is constructed with 12-year records (2002–2013) for the 36 major cities in China. We apply the discrete-time hazard model to analyze cities’ decisions on the adoption of IBTs in the domestic water sector. The sample used for this portion of our analysis is smaller, for two reasons. First, because our sample period started from 2002, we exclude from the analysis two cities, Shenzhen and Xiamen, that had already adopted IBTs by 2002. Second, each city could have at most one observation in IBT status, i.e. the first year of IBT adoption, in the sample. For cities that adopted IBTs during the sample period, observations since the second year of IBT adoption are dropped, in consideration of the possibility of reverse causality from IBT adoption on city characteristics. Cities that had not joined the IBT initiative by the end of sample period are considered to be censored and have all 12 years’ records included in the sample.

Table 1 reports the mean of each variable for the years 2002 and 2013, respectively. To make the year-to-year statistics comparable, we report the sample means of all 34 cities (with Shenzhen and Xiamen excluded) for both years. Besides the variables discussed above, we also control for time trend in all regressions. Log of time trend is chosen as the baseline hazard function and controlled for to capture the pattern of duration dependence in the adoption of IBTs (Stata 13 documentation 2013).

5. Results

We report in columns 1 and 2 of Table 2 the estimated coefficients from logistic and cloglog specifications. Similar results are obtained. Due to the nonlinearity of the logistic and cloglog hazard functions, the magnitudes of the estimated coefficients by themselves are not useful, but the signs of coefficients reveal the direction of partial effects of each explanatory variable on the response probability (Wooldridge 2012). Hence our discussion focuses on the direction of the effect of each variable on the probability of adopting IBTs and the statistical significance of the variables at conventional levels.

Log of time trend is used to control for duration dependence. Its coefficient is positive but insignificant. By replacing the log of time trend with linear time trend or quartic polynomial of time trend, we still cannot attain any significant effect. This suggests that the likelihood of adopting IBTs did not increase over the years.

Lagged change in the ratio of domestic water consumption to total public water supply is found to have a negative and significant effect on IBT adoption. This suggests that a city experiencing a sudden increase in the relative importance of domestic water demand was less likely to adopt IBT in its domestic water sector. That could be attributable to three factors. First, the rise in the relative importance of domestic water consumption may have boosted the bargaining power of the domestic customers. Second, households might be reluctant to endorse any water
price adjustments including IBT adoption, which are usually accompanied by water price increase. Third, decision makers aware of the rise in the relative importance of domestic sector and households’ reluctance to water price adjustments may have been cautious in carrying out IBTs, which are more challenging to implement than linear tariffs.

We find that cities with high leakage rates postponed their decisions to adopt IBTs. This hesitation to introduce IBTs could be explained in several ways. High leakage rate in a water supply indicates low management efficiency in the water utility. On the one hand, utilities with heavy leakage might encounter extreme costs in the maintenance of the network of pipes and (or) installation of meters. On the other hand, the implementation of IBTs requires regular and accurate tracking of water consumption, which further challenges the capability of the utility.

Results show that wastewater treatment rate had positive and significant effect on the likelihood of adopting IBTs. This finding indicates that a city would consider local conditions on both water supply and sewage treatment when making the decision to adopt an IBT structure.

The rise in the adoption of IBTs in major cities has been accompanied by the entry of FDI into the water industry and consequent restructuring of water utilities. While it is expected that FDI and (or) restructuring might bring advanced management concepts into the conventional water sector, their involvement is found to delay IBT adoption in the sample and years covered by our study. This result could be attributed to two factors. First, profit-driven water utilities, such as those involving FDI, can be more prudent than public utilities in selecting the most suitable pricing structure for their respective cities. In view of the necessity of installing individual meters at household level, which can incur overwhelming financial burdens, it is not surprising that a profit-driven water utility might decline to adopt IBTs that may make it difficult to realize net revenue stability (Boland and Whittington 1998). Moreover, it is not necessary for an independent water utility to closely follow national government guidelines, while administrators of a utility that is under control of a nonprofit water bureau and (or) subsidized by government may find their independence in decision-making undermined.

While it is not surprising that positive change in economic development, measured by lagged growth rate of real GDP per capita, would raise the likelihood of adopting IBTs, it might at first glance seem unusual that cities with better economic development, measured by log of real GDP per capita, proved less likely than other cities to adopt IBTs. This may be because it is more difficult to implement IBTs in cities where economic development level is high, as those cities are usually larger in both size and population and may need more time and effort to prepare for the adoption.

We did not find statistical evidence to support a positive relationship between IBTs adoption and the pressure to supply enough water to meet escalating demand as the coefficients on both total water supply and growth rate in total water supply from $t - 2$ to $t - 1$ are insignificant. Similarly, we could not find significant effect of water resource at the provincial level on adoption of IBTs. Assuming that the average provincial water resource reflects the water resource level of the major cities located in the same province, this result reveals that the likelihood of adopting IBTs might not be driven by water resource constraint, a finding similar to the case in Portugal where the use of IBT structure was not specifically a consideration in water scarcity (Monteiro and Roseta-Palma 2011). Also note from Appendix B that, except for Taiyuan, the first block in cities with IBT structure in 2013 is set at more than 10 tons per household per month, more than enough to cover normal water needs. It suggests that the national government’s policy target of using IBTs to fight constraints on water resources seems to have been missed.

Neither rate nor times of water price change from 2000 to $t - 1$ is found to have a significant effect on the likelihood of adopting IBTs. As we assumed that social resistance could not only postpone but also accelerate IBT adoption, no detectable effect found for social resistance could be attributed to either the offset of two effects or the small effect sizes themselves.

Overall, our results indicate that leakage rate, wastewater treatment rate, level of independence of water utility, and economic development level affected a city’s decision regarding the adoption of IBTs during the study interval. Besides the status variables, negative change in the relative importance of domestic water consumption and positive change in economic development are shown to have sped up adoption.

The installation of individual meters within households determines whether household water consumption can be accurately measured and is considered a key factor in IBT adoption. Unfortunately, information on metering rates is not available for all major cities during the study interval, but Table 3 shows the best we could find. If cities with higher metering rate are more likely to adopt IBT and also have a higher level of economic development, then failing to control for metering rate in the analysis would bias the estimation of the coefficient on the GDP. To shed some light on the effect of metering rate on IBT adoption decision, we calculate the Pearson product-moment correlation coefficient between household metering rate in 2008 and the indicator of IBT adoption announcement by 2008 for these selected cities. The correlation coefficient is low at 0.077, which suggests that metering rate may not be an important factor for IBT adoption. Our finding is further supported by the observation that in 13 of

### Table 3. Water meter coverage in selected cities in 2008.

| City       | Household with individual water metering (%) | Announcement year of IBT | Whether adopting by 2008 |
|------------|---------------------------------------------|--------------------------|-------------------------|
| Hangzhou   | 90                                          | Not by 2013               | 0                       |
| Qingdao    | 83                                          | Not by 2013               | 0                       |
| Nanjing    | 75                                          | 2006                     | 1                       |
| Wuhan      | 75                                          | 2006                     | 1                       |
| Guangzhou  | 66                                          | 2012                     | 0                       |
| Ningbo     | 60                                          | 2006                     | 1                       |
| Hefei      | 60                                          | 2010                     | 0                       |
| Fuzhou     | 50                                          | 2004                     | 1                       |
| Kunming    | 50                                          | 2002                     | 1                       |
| Dongguan   | 50                                          | 2008                     | 1                       |
| Harbin     | 42                                          | Not by 2013               | 0                       |
| Jinan      | 22                                          | Not by 2013               | 0                       |
| Xian       | 16                                          | Not by 2013               | 0                       |
| Huizhou    | 13                                          | 2010                     | 0                       |
| Taiyuan    | 10                                          | 2008                     | 1                       |

Notes: Metering data is from the report written by h2o-China in 2008, “Research on Household Water Metering in China,” http://news.h2o-china.com/html/policyandmarket/marketanalysis/70111206408394_1.shtml.

Data on announcement year of IBT are from the website of water group or water bureau in each city.
the 16 cities that had adopted IBTs a linear tariff was reserved for households without individual meters. A This indicates that the coexistence of IBTs and linear tariffs makes the adoption of IBT possible in cities with low metering rates.

In our robustness tests, we attempted to control for extra variables, such as net profit of water utility, population density, average household disposable income per capita, and Gini coefficient of the city. Nevertheless, our estimation results were not affected, and these factors were not found to have significant effects on IBT adoption, either individually or jointly. We might still have neglected some factors that arise in the minds of policy makers, but the possibility is likely to be low, since we included the explanatory variables by mimicking the procedures of decision making on IBT adoption.

Small sample size could be another drawback in our analysis. As mentioned earlier, our analysis is based on 12-year data from major cities in China. There are only 36 major cities in China, but there are in total 658 cities at county level and above. Future studies could expand the sample by including cities in different administrative levels, in order to estimate IBT adoption more precisely and to gain further understanding of the pattern of adoption in cities at different levels.

6. Conclusion

Our analysis of adoption of IBTs in 34 major cities in China from 2002 through 2013, using a discrete-time hazard model, shows that the adoption of IBTs in these cities was affected by only a few clear determinants: relative importance of domestic water demand, leakage rate, wastewater treatment rate, water utility’s type of business structure, and growth rate of the city’s economy. Other factors we considered—total water supply and its lagged growth rate, the stock of water resource, and social resistance to water price adjustment—show no detectable effect on the decision.

Our analysis suggests that it is unrealistic to meet the target for much wider implementation of IBTs in cities at county level and above by the end of 2015, as set by national government in 2013. It might be possible to speed up the adoption process by helping water utilities and cities prepare ahead for eventual implementation, for example, by improving the performance of a city’s water utility, bringing in a wastewater treatment system, switching the water utility’s type of business structure, and promoting the city’s economic growth, although cities may have less flexibility over some other factors, such as lowering the relative importance of a city’s domestic water sector. However, the overall IBT initiative may still encounter at least three challenges. First, preparations for IBT adoption and implementation would be costly and time-consuming. For example, lowering a water utility’s leakage rate would require repair and replacement of the pipeline network and installation of household meters. Second, national policy for adopting IBTs was launched at a time when water utilities were becoming corporatized, but the administrative restructuring of water utilities has proved to be an obstacle to adoption. Third, although IBTs are advocated by the national government, their advantages over other pricing structures are still under debate. Lacking persuasive evidence of the outcomes touted by advocates of IBTs, undecided cities might see few incentives to take action.

Notes

1. The developing countries defined here are countries not among the 37 advanced economies grouped in World Economic Outlook by International Monetary Fund (2015).
2. “Major cities” here refers to capital cities of provinces and municipalities under the jurisdiction of national government.
3. According to China City Statistical Yearbook (2014), there were 658 cities at county-level and above in China by the end of 2013.
4. Shenzhen, China’s first Special Economic Zone (SEZ), located in Guangdong province, adopted IBT in 1990 and was the first city adopting IBT in China. Xiamen, the capital city in Fujian province, adopted IBT in 1999.
5. Detailed information of the 36 major cities’ characteristics in 2013 and water pricing structure in 2013 could be found in online Appendix A and Appendix B.
6. \( t \) is the present year. The growth rate is lagged, from \( t – 2 \) to \( t – 1 \), \( t = 2002, \ldots, 2013 \).
7. In cases involving an IBT structure, the first block (lowest) water price is used for calculations.
8. For households with shared meters, the water bill is split by readings from sub-meters if they are available, although these meters are not under administration of water utilities. All major cities were implementing volumetric tariffs during the sample period (2002–2013).

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