Increasing Block Tariffs, Fairness and Efficiency

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Introduction

There are two related sources of inefficiency the pricing of urban water in Australia today:

- inflexible prices and
- increasing block tariffs (IBTs).

Richard Tooth and I develop a model to analyse the impact of IBTs in a systematic way:

- consumers have heterogeneous ordered demand
- face a volumetric rate with at most two tiers (at most one threshold)

Water authority

- faces a constraint on water availability
- must cover economic costs
The Model

Assume consumers’ demand are ordered by a parameter, $\alpha$, such that:

$$X(\alpha, p) = \alpha x(p)$$

where $\alpha \in [\underline{\alpha}, \bar{\alpha}]$ and where $p$ is the consumer’s marginal benefit.

Number of type $\alpha$ customers $g(\alpha)$

- number of customers type $\alpha$ or below $N(\alpha)$
- total number of customers $N^T$

Assume a given total demand for water, $X^T$. 
Efficient two part tariff

A two part tariff consists of:

- a fixed charge $T$, and
- a single volumetric rate, $\tau$.

The efficient volumetric rate, $\tau^*$, of two part tariff clears the market:

$$X^T = \hat{\alpha} \chi(\tau^*)$$

where $\hat{\alpha}$ is the average demand of all customers.
Total Revenue from the efficient two part tariff:

\[ R^T = N^T\tau^* + \tau^* \hat{\alpha} x(\tau^*) \]

where \( N^T \) is the total number of consumers. The water corporation’s total cost, \( C^T \), is:

\[ C^T = F + cX^T \]

where \( F \) is the fixed cost and \( c \) is marginal cost. Cost recovery requires the fixed charge to be:

\[ T = \frac{[F - (\tau^*-c)\hat{\alpha} x(\tau^*)]}{N^T} \]
Increasing Block Tariffs

The IBT \(\{\tau_1, \tau_2, \tilde{X}\}\) requires the volumetric rate, \(p\), for the \(X^{th}\) unit is:

\[
p = \begin{cases} 
\tau_1 & \text{for } 0 \leq X \leq \tilde{X} \\
\tau_2 & \text{for } X > \tilde{X}
\end{cases}
\]

where \(\tilde{X}\) is the threshold.
Result 1: Suppose that $X^T$ is fixed. Then: (i) $\tau_1 < \tau^* < \tau_2$ (ii) a decrease in $\tau_1$ while holding $\tilde{X}$ fixed requires $\tau_2$ to be simultaneously increased, and (iii) an increase in $\tilde{X}$ requires either $\tau_1$ and/or $\tau_2$ to be simultaneously increased.
Note there are \([N(\hat{\alpha}_2)-N(\hat{\alpha}_1)]\) threshold customers.

**Result 2**: Suppose the water corporation is subject to cost recovery and \(X^T\) is fixed. An increase in \(\tilde{X}\) accompanied by a simultaneous increase in \(\tau_2\) requires an increase in the fixed charge if the number of threshold customers is relatively small and \(\hat{\alpha}_1\) is sufficiently greater than \(\alpha\).

If restrictions used to stabilise demand this effect is stronger.
Result 3: Suppose the number of threshold customers is relatively small. Then a customer type $\alpha$, who’s demand is sufficiently larger than $\alpha$, prefers (i) a threshold such that $\alpha \in [\tilde{\alpha}_1, \tilde{\alpha}_2]$ and (ii) a zero tier 1 volumetric rate.

- Fixed charge must be higher to cover shortfall of revenue for low tier.
- Low demand customers do not benefit much from low rate in first tier
- But face the increase in the fixed charge
- If the threshold is sufficiently large, then low demand customers face a higher bill
- If the threshold is not too large, then very high demand customers may be worse off.
Assume:

- that $\alpha$ is distributed uniformly between 1 and 10.
- Total water availability $X^T = 550$
- The total number of customers is 100.
- Demand of type $\alpha$ customers is $X = \alpha p^{-0.2}$
- the efficient volumetric rate is $\tau^* = 1$ but the tier 1 rate is $\tau_1 = 0.5$.

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Result 4: Suppose $X^T$ is held fixed by variations in $\tau_2$. The DWL is increased if: (i) $\tau_1$ is decreased while holding $\tilde{X}$ fixed increases, and (ii) $\tilde{X}$ is increased while holding $\tau_1$ fixed.
A fair and efficient pricing mechanism

An IBT is modified by the introduction of an additional payment to households.

- Top tier has the efficient volumetric rate, \( \tau^* \).
- Households consuming below the threshold receive a rebate of \((\tau^* - \tau_1)(\tilde{X} - X)\).

With the rebate introduced, the customer faces the bill, \( b(X) \), for consuming \( X \) units, where:

\[
b(X) = \begin{cases} 
T + \tau_1 X - (\tau^* - \tau_1)(\tilde{X} - X) & \text{for } 0 \leq X < \tilde{X} \\
T + \tau_1 \tilde{X} + \tau^* [X - \tilde{X}] & \text{for } \tilde{X} < X 
\end{cases}
\]
Note that algebraic rearrangement of the household bill gives:

\[ b(X) = T - (\tau^* - \tau_1) \tilde{X} + \tau^* X \quad \text{for all } X \]

Type \( \alpha \) customers choose to consume the efficient level of water, i.e. \( X = \alpha x(\tau^*) \).

The revenue from type \( \alpha \) customers is thus:

\[ R(\alpha) = \frac{F - (\tau^* - \tilde{c}) \hat{\alpha} x(\tau^*)}{N^T + \tau^* \alpha x(\tau^*)} \]

We have:

**Result 5**: Under the modified IBT:

(i) consumption is efficient,

(ii) the fixed charge is increased by either an increase in \( \tilde{X} \) or a decrease in \( \tau_1 \),

(iii) household bill are invariant to changes in \( \tilde{X} \) or a decrease in \( \tau_1 \).
Conclusion

Our paper uses an economic model to highlight the impacts of adoption of IBTs

Our model suggests IBTs:

- Can harm low demand consumers
- Induce economic inefficiency

The lower is the tier 1 rate, or the higher is the threshold, the greater is these effects.

‘Average demand’ consumers win from IBTs.

The modified IBT overcomes these problems

- Appearance of fairness is an example of ‘framing’