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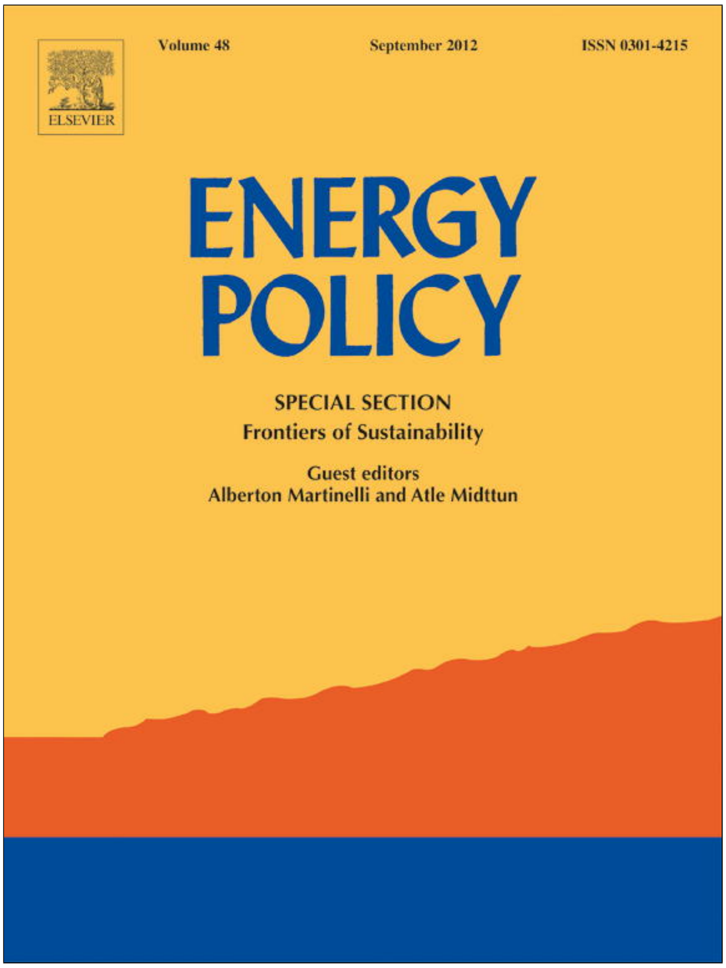
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Forum

Lin, B., Jiang, Z, 2012. Designation and influence of household increasing block electricity tariffs in China. Energy Policy 42, pp. 164–173: How biased is the measurement of household's loss?

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HIGHLIGHTS

- Lin and Jiang (this journal) design a block tariff for households in China.
- They calculate households' responses by using a constant price elasticity estimate.
- But, they use the trapezoid approach to measure the loss in households' surplus.
- This combination causes a significant bias, given the high prices of the new tariff.
- I correct for it by assuming an underlying isoelastic demand function.

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ABSTRACT

The three-tier inclining block tariff ("IBT") issued by the Chinese government in 2010 is focusing attention of energy economists, among whom Lin and Jiang (2012. Designation and influence of household increasing block electricity tariffs in China. Energy Policy 42, 164–173) who assert that the issued tariff is unsuited to meet the social and environmental objectives it was designed for. These authors offer an alternative four-tiered IBT, the performance of which they show by evaluating its welfare and income distribution effects taking the current uniform tariff as reference. To measure the surplus loss to a representative household in a given block the authors use the trapezoid approach. But, because of the limited data on demand, they calculate the household's response by using a constant point estimate of the own-price elasticity of electricity demand. In this note I show there is an incompatibility between these two modeling assumptions. Combining them is causing an upward bias in the surplus loss, which is of significance given the large price change associated with the IBT. I then offer a correction to this bias.

1. Introduction

In their paper about household electricity demand in China, Lin and Jiang (2012) suggest some improvement in the three-tiered inclining block tariff (IBT) issued by the Chinese government in 2010.[1] According to these authors, the issued IBT would fail to simultaneously meet the two objectives it was designed for: to relieve the pressure on low-income households and to encourage energy saving by setting higher prices to consumption volumes that exceed the essential needs. They suggest an alternative four-tiered IBT which charges higher prices within blocks two and three of the three-tiered tariff, and includes one extra block. Then, they evaluate its welfare and income distribution effects taking the existing uniform tariff as reference.

Lacking the relevant data the authors cannot estimate the elasticity parameter of the demand function for a representative household in a given block; thus, they decide to measure a representative household's response by using some approximation. The method consists in equating the standard elasticity ratio to a point estimate of the own-price elasticity of electricity demand found in previous literature. The representative household's response (the final quantity) thus becomes a function of the initial quantity (the block's upper bound), the proportional change in price and the elasticity estimate. To calculate the

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[1] As far as I know, the issued tariff has not yet been adopted; see also Wang et al. (2012) who did an econometric investigation of public acceptance vis-à-vis the issued tariff.

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household's loss they then use the trapezoid formula taking the structure of the IBT into account. This method can be found in Freund and Wallich (1997) who analyze the welfare and distribution effects from raising household energy prices to different segments of the Polish population but in the simpler case of "uniform" tariffs.

In this note *I* show there is an incompatibility between the trapezoid approach and the constant point elasticity assumption. The rationale for this is that in adopting the trapezoid approach for measuring the change in household's surplus, the authors *explicitly* assume a linear demand function. On the other hand, in using a constant point estimate for the own-price of electricity demand, the authors implicitly assume an underlying log-linear demand function.

In this note I show this combination is causing an upward bias in the surplus loss (Section 2). Had the price increase been small, this bias would indisputably be small too. But, the IBT introduced by the authors is associated with large price changes, which is exactly the situation in which the constant point elasticity is most misleading. I offer a solution to that problem whilst retaining the trapezoid approach (Section 3). I show that Lin and Jiang's point elasticity estimate can be used to calculate the surplus loss provided one applies a correction to the final quantity that would be derived from an underlying isoelastic demand. I then discuss the relative merit of that solution and conclude (Section 4).

2. Lin and Jiang's incompatible assumptions

Lin and Jiang (2012) consider the surplus loss ("DCS" in their paper) of a representative household for each tier of their IBT. To keep this note concise, I focus on the surplus loss in the second block, following their notations as closely as possible (see Fig. 1). The lifeline quantity they impose is 40 kWh (q_1). The second block's upper bound is 80 kWh (q_0). They set the following values for the corresponding prices. Under their IBT, the first block's (lifeline) price, p_1, is set equal to the price currently charged in China (CNY 0.55/kWh) whereas the price p_2 set for the second block is equal to CNY 0.75/kWh.[2]

Lin and Jiang calculate DCS by using the change in Marshallian consumer surplus (the area of a trapezoid), that is:

$$\mathrm{DCS} = \frac{q_2+q_0}{2} \times (p_2-p_1) - q_1(p_2-p_1) \quad (1)$$

DCS takes the particular structure of the IBT into account, hence the second term at the right hand side of this equation which represents an implicit subsidy for consumers in block 2 (see Ruijs, 2009 for a definition). The error in Lin and Jiang (2012) stems from equating Dalton's upper elasticity formula to an estimate ($e \equiv -1/4$) suggested in previous literature,[3] that is:

$$\frac{(q_2-q_0)/q_0}{(p_2-p_1)/p_1} = e \quad (2)$$

From (2) they deduce q_2:

$$q_2 = q_0(1+e(p_2-p_1)/p_1) \quad (3)$$

Substituting (3) for q_2 in (1) gives the following measure for the change in household's surplus:

$$\mathrm{DCS} = q_0(p_2-p_1)\left[1+\frac{e}{2}\left(\frac{p_2-p_1}{p_1}\right)\right] - q_1(p_2-p_1) \quad (4)$$

What Lin and Jiang overlooked is the fact that (3) represents a tangent approximation (line T in Fig. 1) to an isoelastic demand curve about the basis point (q_0,p_1). For e is supposed to be a constant point elasticity whereas the elasticity varies with price when demand is linear; thus, depending on the estimate used for e, the calculated household's response could either be q_2 or q_2' as shown in Fig. 1.

3. A solution

In this section I show that Lin and Jiang's point elasticity estimate can nevertheless be used to calculate the surplus loss provided one applies a correction to the final quantity. Let us consider (q_0,p_1) as the 'base' point on the demand curve corresponding to the initial price p_1 and (q_2,p_2) as the arc end point (see D_I in Fig. 1). Under these notations, we know from Vázquez (1998, p. 553) that $-1/4 = [\ln(q_2)-\ln(q_0)]/[\ln(p_2)-\ln(p_1)]$, regardless of the span of the arc. To put it less formally, it is only when the demand curve passing through the arc end points has a constant point elasticity that the arc elasticity can equal that value. Using that equality we obtain:

$$q_2 = q_0 \times (p_2/p_1)^{-1/4} \quad (5)$$

But, the elasticity measure (2) as used by Lin and Jiang does no satisfy that equation for it is implicitly formulated under the incompatible assumption of a linear demand function and a small, yet finite price increase. In fact, the price change that Lin and Jiang apply to households in the second block is quite significant: $100 \times (0.75-0.55)/0.55 = 36.4\%$. In this situation the equation $\ln(q_2)-\ln(q_0) = -1/4[\ln(p_2)-\ln(p_1)]$ is not well approximated by $\tau_q = (-1/4)\tau_p$. Or equivalently, (5) is not well approximated by $q_2 = q_0(1-\tau_p/4)$ that is Eq. (3).

Only for a small price change, this latter approximation is acceptable because $(p_2/p_1)^{-1/4} = (1+\tau_p)^{-1/4} \approx 1-\tau_p/4$ when $\tau_p \approx 0$. For example, when applying this formula for a 10% price increase from the base point we find $q_2 = 79.8012$ with the correct formula and 79.80 with Lin and Jiang's approximation. But for the price increase applied by Lin and Jiang to a typical household in block 2 ($\tau_p = .364$), the formula starts to break down. We obtain $74.03 > 72.72$.[4]

Unfortunately, the non-linearity of (5) makes its combination with the trapezoid formula difficult. We can remedy that difficulty by replacing $(p_2/p_1)^{-1/4} = (1+\tau_p)^{-1/4}$ with its quadratic approximation about the expansion point $\tau_p = \tau_0$, that is $(1+\tau_p)^{-1/4} \approx (1+\tau_0)^{-1/4} - (1/4)(1+\tau_0)^{-(1/4)}(\tau_p-\tau_0)$. Let τ_0 be equal to zero, we obtain $(1+\tau_p)^{-1/4} \approx 1-\tau_p/4+5\tau_p^2/32$. Therefore:

$$q_2 = q_0\left(1+e\frac{p_2-p_1}{p_1}+\frac{e(1-e)}{2}\left(\frac{p_2-p_1}{p_1}\right)^2\right), \quad (6)$$

where $e \equiv -1/4$. We find $q_2 = 74.380$. Using the trapezoid formula for the change in consumer surplus, we obtain:

$$\mathrm{DCS} = q_0(p_2-p_1)\left[1+\frac{e}{2}\left(\frac{p_2-p_1}{p_1}\right)+\frac{e(1-e)}{4}\left(\frac{p_2-p_1}{p_1}\right)^2\right] - q_1(p_2-p_1) \quad (7)$$

[2] The precise values of both prices and quantity are not crucial to the discussion of Lin and Jiang's paper. What really matter are the relative magnitudes of prices and quantities.

[3] We notice this value is very close to the short-run median value of -0.3 which Espey and Espey (2004) found in the meta-analysis of the price and income elasticities of electricity demand.

[4] We can further illustrate the problem. For a representative household in block 3 (the assumed elasticity by Lin and Jiang is -0.158 in this case and maximum consumption 180 kWh), the values respectively are 140.72 with Lin and Jiang's approximation and 163.01 using our formula.

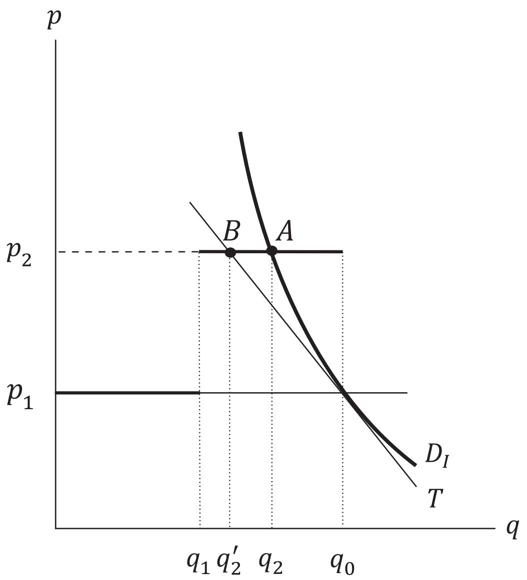

Fig. 1. First and second tiers of the issued and Lin and Jiang's IBTs.

Of course, Eq. (6) gives a value of q_2 that is not too distant from that given by the approximating formula of Lin and Jiang. It is however closer to point *A* (slightly above, actually) than to point *B* as expected. The rationale for this is twofold: (6) uses the same value for the price elasticity ($e \equiv -1/4$); second, it only is an approximation to (5), given *e*.

4. Discussion and conclusion

Not surprisingly, our measure of the final quantity (or the change in consumer surplus, respectively) is greater (less) than that found by Lin and Jiang for a representative household whose demand is in block 2. Some readers might find our measure perhaps too sophisticated for practical applications; others may instead argue that a Taylor expansion towards higher degrees ought to be used. Nevertheless, in assuming an underlying isoelastic demand, our solution to q_2 has an advantage that it is compatible with the own-price elasticity estimate used by Lin and Jiang, whilst retaining the trapezoid approach.

I conclude, in short, that before Lin and Jiang's method can be used effectively to evaluate the welfare effects of an IBT in China, the compatibility between the demand schedule and the price elasticity assumption should first be checked; accordingly, *I* recommend the following guideline: if the demand function is known, calculate the surplus loss in integral form; otherwise, check if the magnitude of the outside elasticity estimate is not too large; if it is small (less or equal than 10% say) uses Lin and Jiang's approach; but, if it is large then use our solution assuming demand is isoelastic.

References

Espey, J.A., Espey, M., 2004. Turning on the lights: a meta-analysis of residential electricity demand elasticities. Journal of Agricultural and Applied Economics 36, 65–81.

Freund, C., Wallich, C., 1997. Public-sector price reforms in transition economies: who gains? Who loses? The case of household energy prices in Poland. Economic Development and Cultural Change 46, 35–59.

Lin, B., Jiang, Z., 2012. Designation and influence of household increasing block electricity tariffs in China. Energy Policy 42, 164–173.

Ruijs, A., 2009. Welfare and distribution effects of water pricing policies. Environment and Resource Economics 43, 161–182.

Vázquez, A., 1998. An alternative definition of the arc elasticity of demand. Journal of Economic Studies 25, 553–562.

Wang, Z., Zhang, B., Zhang, Y., 2012. Determinants of public acceptance of tiered electricity price reform in China: evidence from four urban cities. Applied Energy 91, 235–244.